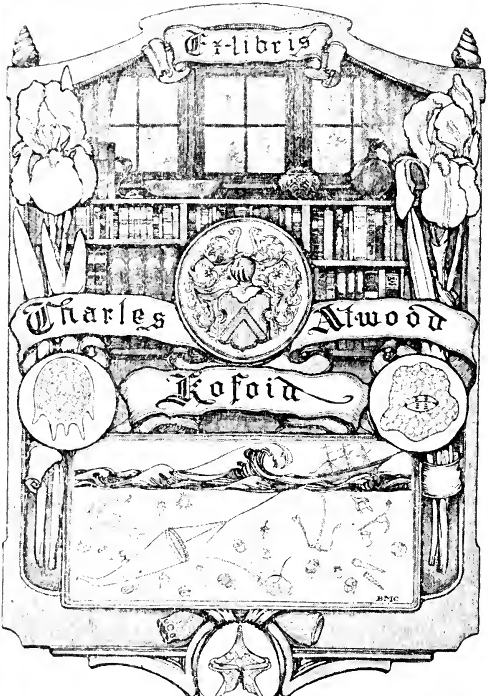
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A

HANDBOOK

OF

MEDICAL MICROSCOPY.

BY

JOSEPH G. RICHARDSON, M.D.,

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PHILADELPHIA:

J. B. LIPPINCOTT & CO.

1871.

TO THE

MANAGERS OF THE PENNSYLVANIA HOSPITAL,

THROUGH WHOSE LIBERALITY

HAS BEEN OBTAINED A LARGE PART OF ITS ILLUSTRATIVE MATTER,

This Little Work

IS RESPECTFULLY DEDICATED

BY

THE AUTHOR.

PREFACE.

THIS book owes its origin to a belief entertained by the author that there exist in the profession an increasing sense of the importance of microscopic research, and a growing desire to render its advantages available in the routine of daily practice. Estimating, as we probably may, that at least one-half the cases of disease which physicians are called upon to treat, would have some light thrown upon their nature by a careful examination of the renal secretion, sputum, blood, etc. with the microscope, it seems obvious that an earnest and conscientious practitioner of medicine can scarcely discharge his whole duty to himself and his patients without frequent resort to such investigations; and in order to promote this habit among medical men, who are too busy to search through the elaborate and expensive manuals already before the public, the following pages have been prepared, with special reference to the *purely practical* in Microscopy. In order to meet the demands of those who, from any cause, have been prevented from acquiring or *retaining* a due familiarity with the instrument and its requisite manipulations, a constant effort has been made to describe every step of the processes recommended, great care being taken to enter into and fully elucidate all those minute but important details, which, because they seem so simple to the skillful observer, have generally been passed over without particular explanation. Especial attention has also been paid to pointing out the mistakes into which an inexperienced microscopist is liable to fall from errors of observation or deduction.

While protesting against the doctrines of that French school which seems to vaunt clinical observation by the

unaided senses alone, the author has continually endeavored to inculcate the use of the microscope only as an aid to, and intimate associate with, every other means of investigating disease, as has been his custom in performing his duties of Microscopist to the Pennsylvania Hospital in this city, the unrivaled clinical advantages of which have afforded sundry illustrative cases detailed in the work. In addition to this original material, some new observations upon Albuminuria, on the detection of Blood-stains, in regard to the identity of Salivary, Pus, and White blood corpuscles, and on the recognition of Lung-tissue as an aid to the *early* diagnosis of Consumption, described in their respective places, are now first given to the profession in a permanent form.

The body of the manual is arranged, it is believed, more thoroughly than any previous work of its kind, upon a sort of natural system, and, as far as practicable, in accordance with the so-called Dichotomous plan, having therefore the great advantage of presenting problems of Diagnosis as they occur in actual practice. By this method, as will be seen on reference to the Table of Contents and to Chapter VII., while different secretions and excretions form a basis of classification, classes are divided, according to the naked-eye characteristics, into orders, after which the microscopic appearances point out the generic and specific peculiarities that serve to distinguish the special malady existing, and so conduce to those great ends, as physicians deem them, of microscopic study, the more accurate Diagnosis, Prognosis, and Treatment of disease.

The figures contained in the original wood-cuts are, with one or two trifling exceptions, Camera Lucida drawings from actual specimens, and all exhibit, as accurately as the author's delineations have sufficed to reproduce them, the exact appearances presented to the eye in the field of the microscope.

No 1603 Arch St., Philadelphia.

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MEDICAL MICROSCOPY.

CHAPTER I.

THE MICROSCOPE.

As a full exposition of the optical principles upon which achromatic microscopes are constructed would require many pages of description, illustrated by numerous drawings, I must content myself with briefly explaining in regard to the simple microscope, with which all are so familiar in the form of a pocket magnifying-glass, that it depends for its efficacy, first, upon the fact that objects appear to us larger or smaller in proportion to the distance they are held from the eye, and the consequent angle included between the rays of light given off from their extremities; and, second, on the power which convex lenses possess (by virtue of the laws of refraction of light on passing from a rarer to a denser and from a denser to a rarer medium) of converging the pencils of rays of light emitted from every part of an object, so that the humors of the eye can bring them to an exact focus (upon the retina) when that object is held much nearer to the eye than is otherwise compatible with distinct vision. Thus, for example, an inch rule held at the distance of five inches from the eye will appear twice as long as one held at the distance of ten inches, and a similar rule held at the distance of one inch will seem ten times as long as

that at ten inches; but its parts will be very indistinct until we interpose a double convex lens whose focal length is one inch, through which its details will all be seen clear and well defined, while its apparent magnitude will still be ten times that of the inch rule held at ten inches. Moreover, not only are the individual rays of each pencil of light rendered more convergent, but the direction of the pencil itself is changed, so that the different pencils from opposite extremities of an object enter the eye at a greater angle, and consequently present an image larger than the object actually is, although, practically, this does not seem to add much to the capacity of a lens; for opticians having arbitrarily fixed upon ten inches as the standard of distinct vision, a lens of an inch focus, enabling one to see any object *distinctly* at the distance of about an inch, is stated to magnify that object ten times linear, or ten diameters; while a lens of one-tenth of an inch focus magnifies ten times ten, or one hundred diameters.

The simple microscope—by which is meant one composed of a single lens—has, however, long been almost superseded as a means of anatomical and medical research by the compound instrument, consisting of single lenses so arranged that each adds to the power of the other, associated with suitable mechanical apparatus, first, for adjusting the object to be examined at a proper distance; second, for enabling the observer to move it readily, so as to bring different portions into view; and, lastly, for concentrating on it sufficient light to render it clearly visible. The methods of obtaining these three grand desiderata vary, of course, with different manufacturers, some one of whom personal preference, proximity of residence, etc. will render most eligible to the purchaser of a microscope,—so that, while pointing out as well as I can the peculiarities and advantages of each *particular instrument*, I shall earnestly endeavor to do so without preju-

dice, in a thoroughly impartial manner, and solely for the benefit of my readers, seeking to make no attempt at recommending any *particular maker* above his fellow-craftsmen, and fully recognizing the fact that if for one set of purposes the productions of Messrs. A, B & C are best, for another they may be greatly surpassed by the manufacture of Messrs. X, Y & Z. Most dealers in optical instruments and apparatus furnish catalogues with prices annexed, which can be obtained on application by letter or personally, as directed in Appendix A.

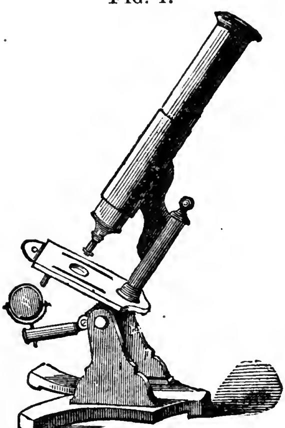
Among those physicians and students who contemplate the purchase of a microscope for the purpose of aiding them in the practice of their profession, there will, of course, be some to whom the question of expense is of but minor consideration, provided they obtain a satisfactory instrument; others, again, who may have neither leisure nor inclination for anything but ordinary office-work in the routine of practice, would consider the expenditure of more than a moderate sum injudicious, in view of the time which they could devote to the subject; while others still (and among them many of the energetic young men of the profession), being, in the outset of their career, obliged to practice, in default of anything else, a strict economy, require the least costly instrument which will enable them to solve the problems of microscopical diagnosis.

Although a cheap microscope may be made, by superior care and skill, to answer the purpose of more valuable instruments in four cases out of five where its assistance is sought, yet, as the fifth case is apt to be the one of all others in which its aid is most necessary, my advice is to procure a good instrument, even if you have to borrow the purchase-money for a year or two, feeling confident that the superior accuracy and consequent success which it must insure in the treatment of disease, will enable you

to pay more than a liberal interest upon the loan, and soon to discharge the entire debt; but should this idea of being, even for a time, the slave of a creditor, seem too repugnant, you have still the resource, as above intimated, of compensating for the defects of an inferior instrument by greater patience and assiduity.

The figure in the margin represents the cheapest really efficient microscope with which I am acquainted. It is called Woodward's Student's Microscope, was first arranged many years since by the distinguished Lieutenant-Colonel J. J. Woodward, M.D., of the Surgeon-General's Office, Washington, whilst a teacher of microscopy in this city, and has, I am informed, been largely sold to medical men in all parts of the United States by its present manufacturers, Messrs. J.W. Queen & Co , No. 924 Chestnut, St., Philadelphia. The cast-iron stand, varnished to prevent rusting, is made sufficiently heavy to avoid, as far as possible, any motion of the instrument from the vibration of surrounding objects; the two upright standards are perforated for the reception of a pivot, upon which the remainder of the instrument revolves, in order to adjust it at any angle to the perpendicular most convenient for the observer; the tube or "body" of the instrument slides in another tube, which allows of its being rapidly raised from or lowered toward the stage, so constituting the "coarse adjustment," while the "fine adjustment," or more delicate arrangement, for bringing

FIG. 1.



Woodward's Student's Microscope.

the body with its attached lenses nearer to or farther from the object under examination, is obtained by turning the screw-head back of the body, seen in the drawing to the right of the center; into the upper end of the body slides the "eye-piece," a combination of two convex lenses, the upper being called the "eye-glass" and the lower the "field-glass," whose office it is to magnify the image formed within the tube by the "objective," as the association of three small lenses which screws on to the lower end of the body is called, because it is next to the *object* undergoing examination. The flat, perforated brass plate situated at right angles to the body, and called the "stage," is for the reception of a glass slide carrying the substance to be investigated, and is furnished with two "spring clips," beneath which the slide is placed, and so held securely at whatever angle the instrument may be inclined Beneath the stage, and attached to it by a pivot, on which it revolves, is the "diaphragm," a circular metallic plate, perforated with holes of different sizes, which, by turning the diaphragm, can each be brought successively to the center of the opening in the stage, so as to permit a greater or less amount of light to pass from the mirror below to the object, and through or around it to the objective above. The mirror, which is attached to a jointed arm beneath the stage, is suspended in a movable semicircle of brass, which allows of its adjustment at any angle, in order to permit very oblique illumination to be employed when desired. A large convex lens, called a "condenser," is furnished in addition, attached by a joint to a separate stand, so as to enable the microscopist to examine objects by direct illumination—that is, by concentrating the light of a window, for example, from above upon the stage, a method which can only be satisfactorily employed, however, with the lowest power. The objectives supplied with this instrument are of French manu-

facture (very much cheaper, although sometimes nearly as good as those ordinarily produced by English or American workmen); they are respectively of about $\frac{1}{2}$ inch and $\frac{1}{8}$ inch focal length, the latter being composed of three separate achromatic lenses, which, with proper care, can be safely screwed apart and cleaned on a soft linen rag or piece of buckskin. The first, or upper one of the component lenses forming the $\frac{1}{8}$ inch, employed alone, but assisted by the eye-piece, makes an object appear 100 times as long as it really is; the first and second together magnify about 250 diameters; and the entire combination of all three lenses gives a magnifying power of 350 diameters (*vide infra*). The microscope and accessories, as above enumerated, are furnished complete, and packed in a neat mahogany box, for $55.00.

Mr. W. Y. McAllister, No. 728 Chestnut Street, Philadelphia, furnishes, among others, an achromatic microscope, 13 inches high, with a brass body, to incline at any angle, micrometer movement for focus, movable stage, fitted with one eye-piece and one set of achromatic lenses, giving powers of 100, 200, and 300 diameters, for the extremely moderate price of $42.00, below which it is probably useless to purchase a new instrument with the expectation of its satistisfying the needs of a practicing physician.

Messrs. Queen & Co. also supply an achromatic microscope, with powers ranging from 50 to 650 diameters, for $45.00.

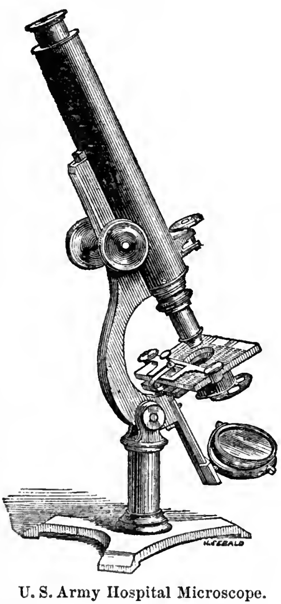
I do not find that the Messrs. Grunow, of New York, furnish any microscopes so low priced as those above described. These gentlemen quote me their least costly stand, with two eye-pieces and condenser, but without any objectives, at $50.00, which, as the $\frac{1}{4}$ inch objective, giving a power of about 200 diameters, is set down at $35.00, would make the total value of the instrument in working order, $85.00.

The Boston Optical Works, R. B. Tolles, Superintendent, furnish a student's microscope (designed under the advice of several of the professors of the Medical School of Harvard College), which is fifteen inches high and weighs six pounds. Its base and uprights of cast-iron, japanned, to prevent rust, have substantially the form of the corresponding parts of Zentmayer's Army Microscope, described on the next page. By means of a trunnion joint the optical portions of the instrument, which are carried by the curved arm, can be placed in any position from vertical to horizontal, a stop being adjusted so as to prevent movement in any direction beyond these limits. The body of the instrument, which slides in a tube at the upper end of the arm, is furnished with a "B" eye-piece, that is, an eye-piece which magnifies nearly one-third more than the lowest (technically called the most shallow, or "A") eye-piece, and two *second-quality* objectives, of 1 inch and $\frac{1}{4}$ inch focal length, giving, when thus combined with the eye-piece, powers respectively of about 60 and 280 diameters. The stage is not movable, but is furnished with spring clips, for holding a slide in position, beneath which the slide bearing the object is to be moved by hand, and below is placed a revolving diaphragm, also a concave mirror, furnished with a joint, so as to admit of the employment of oblique light; for direct illumination of opaque objects, the mirror is removed to an upright stand. The coarse adjustment for the focus is effected by sliding the compound body, which is held in its place by a steel spring, while a fine adjusting movement is obtained by a new method, said to be eminently efficient. Mr. Tolles states that "the stand is made with all the care bestowed on their first-class instruments, and proves satisfactory for the use of amateur students and the ordinary work of the medical profession. The workmanship is superior to that of any instruments of the class made in Europe. The form is that

best adapted for easy and convenient use." Price, in an upright, black walnut case, $70.00. (The same instrument, with fine adjustment on the stage, that is, arranged so that slight changes of focus are effected by apparatus for moving the *stage* to or from the body of the microscope, instead of *vice versa,* is furnished for $50.00.)

The United States Army Hospital Microscope, made by Jos. Zentmayer, of Philadelphia, having been adopted by the authorities at our seat of government as *the one,* among instruments manufactured in this country, best suited on every account to the necessities of the profession, merits, of course, an accurate and detailed description, and may, I believe, be at any time purchased either of the maker or of his agents, J. W. Queen & Co., with a full confidence that it will suffice for all the ordinary wants of a physician.

Fig. 2.



U. S. Army Hospital Microscope.

This excellent instrument (Fig. 2) is supported upon a pillar of brass, connected with a tripod foot of the same metal, has a curved arm, which carries the body (see page 12), and is furnished with a joint by which it can be inclined at any angle best suited to the eye of the observer. The coarse adjustment is obtained by a toothed pinion, working upon a rack, by means of a double milled head, which allows of motion being communicated by either hand, as most convenient, while the fine adjustment is given by a micrometer screw, so arranged to act upon the end of a small lever as to cause a very gradual motion of the

objective to or from the object. The stage consists of an oblong piece of plate-glass, moved by hand, but held in any required position by the pressure of a spring, whose tension is regulated by means of a screw which passes through its extremity. Beneath the stage is placed a tube, to which is fitted a revolving diaphragm, with holes of varying sizes, for allowing of different degrees of illumination. The mirror below the diaphragm is double, one side being plain and the other concave, and mounted so as to admit of the employment of either axial or oblique illumination. The instrument is furnished with a "deep" and a "shallow" eye-piece, 1 achromatic objective $\frac{8}{10}$ of an inch in focal length, giving, with the shallow eye-piece, a power of about 50, and, with the deep, one of nearly 100 diameters, and another objective of $\frac{1}{5}$ of an inch focus (not adjustable for the varying thickness of the thin glass covering the object examined), giving, with the eye-pieces respectively, powers of about 250 and 450 diameters. It is also supplied with a camera lucida, for drawing objects, a stage micrometer, with division lines ruled upon it $\frac{1}{100}$ and $\frac{1}{1000}$ of an inch apart, and a condensing lens two inches in diameter, upon a separate stand; the whole securely packed in a neat walnut box, with a lock and key, for $135.00.

The Messrs. Grunow, of New York, advertise to furnish their Student's Microscope *Stand* (No. 1, *a*) for eighty dollars. The instrument is on a tripod base, and uprights, with joint to incline at any angle. The optical body has quick and very delicate fine focusing motions, the former working by two milled heads, the latter by a fine screw acting upon the end of a lever. The concave reflector is mounted so as to afford oblique as well as axial illumination. The stage is movable in rectangular directions by rack and screw, and its upper surface is formed by a ground-glass plate. The instrument, as quoted, is supplied with two eye-pieces, a condenser for opaque objects, and a

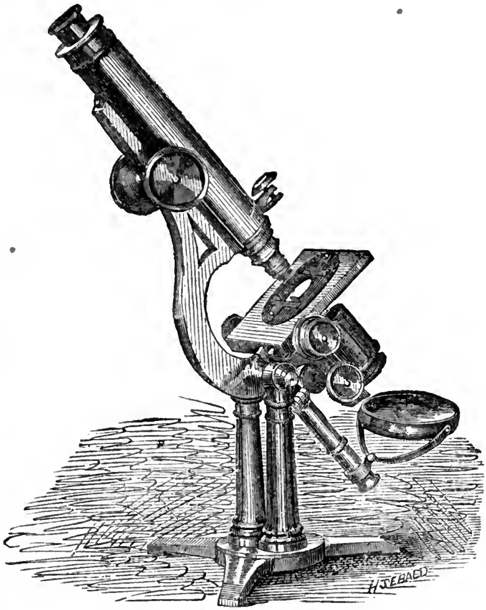
case, but requires, in addition, a 1-inch objective, costing \$18.00, and a $\frac{1}{4}$-inch, costing \$35.00, so that its entire expense, with apparatus, as above mentioned (without the camera lucida and micrometer, but with the screw movement for the stage), amounts to \$133.00.

The Boston Optical Works will manufacture first-class A and B Trunnion Microscopes by special contract. An elegant and complete instrument, made for Robert B. Howland, Esq., President of the Howland Institute for Young Ladies, at my late residence, Union Springs, N. Y., and of whose very superior capacity I can speak from frequent experience, cost \$275.00.

Members of the fortunate class on which the *res angusta domi* does not press, can, of course, when purchasing a microscope, choose their instrument of almost any variety of perfection and price, up to Powell & Lealand's No. 1, Large Compound Microscope, with Binocular Arrangement, costing, complete, £189, or near \$1800 in this country; yet as few such purchasers will procure instruments without comparing those of different manufacturers, not only personally, but with the aid of their numerous friends, it seems unnecessary to describe here many different master-pieces of mechanism all so perfect as to make the selection of any one a difficult problem. As a representative of American workmanship, Zentmayer's Grand Microscope ranks high, and has received from Dr. F. A. P. Barnard, President of Columbia College, N. Y., as Commissioner of the United States to the Exposition Universelle, Paris, 1867, the flattering encomium that "nothing could be more tasteful or elegant than the first-class stands constructed by Zentmayer." This excellent instrument stands nineteen inches high, and is supported upon a tripod base, whose feet diverge sufficiently to insure complete firmness and stability. The two brass pillars, upon which the body and stage are swung, rest upon a revolving plate, with a graduated edge, by which the angular aperture of the ob-

jectives may be ascertained. The body is moved by a double milled head, pinion, and rack for the coarse arrangement, and a fine micrometer screw for the delicate adjust-

FIG. 3.



Zentmayer's Grand American Microscope.

ment. The mechanical stage has a screw adjustment, with milled head, for the horizontal motion, and a delicate chain and pinion, with milled head, for the vertical motion. On the center of the upper side of the stage a circular plate, with a graduated edge, is attached for measuring angles of crystals. The whole thickness of the stage is but $\frac{3}{16}$ of an inch, but it is, nevertheless, perfectly solid and steady, and affords unusual facility for great obliquity of illumination when difficult tests are to be resolved. Under the stage a small tube, with rack and pinion, is attached,

in which the accessory illuminating apparatus is carried when in use. The mirror frame, carrying on one side a plane, and on the other a concave reflector, is mounted upon a jointed bar so as to allow of any required adjustment for oblique illumination. A graduated draw-tube, bearing the eye-pieces, slides in the main body of the microscope, for increasing the magnifying power by lengthening the distance between the objective and the eye-piece. The optical portions proper of the instrument consist of three eye-pieces, A, B, and C; an achromatic objective of $1\frac{1}{2}$ inch focal length and 22 degrees angle of aperture; one objective $\frac{8}{10}$ of an inch focus, 32 degrees angle of aperture, one of $\frac{4}{10}$ of an inch focus, 80 degrees angle of aperture, capable of adjustment for varying thicknesses of thin glass cover, and an objective of $\frac{1}{5}$ of an inch focus, also adjustable for the thin glass cover of the object; the highest power thus attainable being, with the $\frac{1}{5}$ objective and deepest eye-piece, without using the draw-tube, between 600 and 700 diameters. Of accessory apparatus, this microscope possesses a parabola for dark-field illumination, the rays in the axis of the instrument being cut off and the substance examined being viewed as an opaque object; an erector for correcting the inversion of objects produced by the ordinary combination of lenses in microscopes, and chiefly used in making dissections; a polarizing apparatus, with selenite plate, for subjecting objects to the test of polarized light; a condensing lens, on a separate stand, for the direct illumination of opaque objects; a camera lucida, for drawing objects as magnified under the microscope; a stage micrometer, ruled to $\frac{1}{100}$ and $\frac{1}{1000}$ of an inch; a pair of stage forceps for holding small insects, etc., during examination by low powers; an animalcule cage, a zoophyte trough (a glass vessel with flat sides, for the more convenient examination of microscopic animals in the living state), and a blue glass cap, which, fitting beneath the stage, renders the light much less trying to the eye of the observer;

the whole packed in a neat walnut box, and furnished for $386.00.

Supposing, now, that a microscope, whether one of those above described or of some other pattern, has been determined upon, how are the objectives to be selected, and in what way can the purchaser convince himself that he obtains superior lenses? In the first place, I would advise the student to obtain the assistance of some friend more experienced in the use of the instrument than himself in testing the good qualities of the glasses he proposes to buy, assuring him that all the printed directions I am able to furnish toward that end will not be sufficient to enable him to decide this important question nearly as well as can a practiced observer who has had opportunities of working frequently with the objectives of different makers and carefully testing their comparative merits. Few microscopists would be apt to refuse to any brother practitioner of our liberal art so small a favor, and I may say for myself that I shall be glad to assist any readers of my little work by giving them my own opinion (as heretofore not unfrequently called upon to do) in regard to any of the subjects herein attempted to be elucidated; nevertheless, in justice to the opticians above mentioned, with whom I have had more or less extended business transactions, and probably others personally unknown to me, I must say that, although slight variations in the working capacity of lenses furnished under the same name do happen, there is little question that any one may depend upon obtaining glasses of good quality, while, should any accidental error occur, it will be promptly rectified on application. Presuming, however, that some students may lack such opportunity of consultation, I shall detail, as clearly as I can, methods for discovering the points of a good lens under the head of Manipulations, in the next chapter, which see.

Objectives differ in magnifying power, in defining power, or definition, in penetrating power, in flatness of field, and in capacity for adjustment for variations of media through which the object is examined.

The Magnifying Power of an objective, according to the Linear measurement, which is that commonly adopted among microscopists, is the number of times it would apparently enlarge a mathematical line, when so adjusted as to give the most distinct image; thus, for example, an objective of 1 inch focal length, as ordinarily manufactured, will make a line $\frac{1}{10}$ of an inch long appear an inch in length. This, of course, is when used alone in the manner of a common hand magnifying-glass; when it is adapted to the body of the compound microscope, and the image it forms is magnified by an eye-piece which amplifies that image again five times, we obtain an increase of the apparent magnitude equal to fifty times, or fifty diameters linear measurement; so that, for instance, the line above referred to, when thus viewed through the 1 inch objective with the "A," or most shallow eye-piece (no use being made of a draw-tube), would look as if it were five inches in length. It will be seen from this that, theoretically, the magnifying power of a lens bears a definite relation to its focal length; but practically this is not precisely the case, since the mechanical difficulties of grinding and fitting the component lenses produce slight variations in the focal distance, and, of course, in the power, —that is, a lens whose focal length is actually $1\frac{1}{10}$ of an inch, and its magnifying power consequently, when arranged with an eye-piece as above, is about 45 diameters, may be sold as an inch objective; or the error, as is more frequently the case, may be upon the other side, so that the purchaser obtains at the price of an inch objective a lens having an actual power, when combined as described, of 55 diameters. Such variations from the nominal capacity

are unavoidable, and, provided they do not exceed the limits stated above, can scarcely be objected to. One of the most extensive dealers in microscopes in this country informed me that their rule was to make each objective to magnify with the lowest eye-piece on a standard stand, half the number of hundred diameters, signified by the denominator of the fraction, expressing the focal length, *e.g.* a $\frac{1}{5}$ objective, since the denominator of the fraction expressing its focal length when divided by two equals $2\frac{1}{2}$, should magnify 250 diameters. As will be seen by the accompanying table, Messrs. Powell & Lealand, the celebrated London opticians, estimate the magnifying powers of their objectives in a similar manner.

Achromatic Object-glasses for Microscope.

Object-glasses.	Angular Aperture.	Magnifying Power with the various Eye-pieces.					Price.		Lieber-kuhns.
		No. 1.	2.	3.	4.	5.	£	s.*	s.
2 in.	14 degs.	25	37	50	100	150	2	15	10
$1\frac{1}{2}$ "	20 "	37	56	74	150	220	3	0	10
1 "	30 "	50	74	100	200	300	3	3	8
$\frac{2}{3}$ "	32 "	75	111	150	300	450	3	10	8
$\frac{1}{2}$ "	70 "	100	148	200	400	600	5	0	6
$\frac{4}{10}$ "	80 "	125	187	250	500	750	5	5	6
$\frac{1}{4}$ "	95 "	200	296	400	800	1200	5	5	5
$\frac{1}{4}$ "	130 "						7	7	
$\frac{1}{4}$ "	145 "						8	8	
$\frac{1}{5}$ "	100 "	250	370	500	1000	1500	6	6	
$\frac{1}{8}$ "	140 "	400	592	800	1600	2400	8	8	
$\frac{1}{12}$ "	145 "	600	888	1200	2400	3600	12	12	
$\frac{1}{16}$ "	175 "	800	1184	1600	3200	4800	16	16	
$\frac{1}{25}$ "	160 "	1250	1850	2500	5000	7500	21	0	
$\frac{1}{50}$ "	150 "	2500	3700	5000	10000	15000	31	10	

* With gold at 120, and the duty, as at present, 40 per cent. in specie, the pound sterling my be estimated as equal here to nearly $10.00 in currency.

It must not be forgotten, in calculating the powers of various objectives with different eye-pieces, that an inch or two more or less in the length of the microscope body makes an important alteration in the apparent size of the object, a fact which is taken advantage of by means of the draw-tube to enable the observer to increase the magnifying power of an instrument so constructed. The focal length of an achromatic objective is by no means the distance at which an object must be placed from the surface of the front combination,—the latter space being, on an average, less than half the former.

DEFINITION or DEFINING POWER of an objective is that quality which enables it to present the objects it magnifies with clear, sharp, well-defined edges, as if engraved upon the field. Excellence in this respect is the most important attribute of a first-class objective, and constitutes the great point of difference between different lenses of the same focal length.

The PENETRATING POWER of an objective depends, according to the editors of the *Micrographic Dictionary*, "upon two distinct circumstances—the goodness of the defining power and the magnitude of the angular aperture of the object-glass. The degree of obliquity of the light is also of great importance in connection with the latter." The term "penetrating power" is used by some microscopists, more correctly, I think, as having reference to the depth of the stratum of any object (measured in a line with the axis of the microscope) which is in focus at the same time.

FLATNESS OF FIELD of an objective is that quality which causes every part of an object lying in the same plane to be exactly in focus when its central portions are most distinct.

Every good objective must be free from chromatic aberration, at least when combined with the lowest eye-piece; that is, brilliant objects, such as crystals, must be pre-

sented with their outlines sharp and black, without any iridescent margins; with the higher eye-pieces, which so greatly increase the imperfections of an objective, this fault sometimes occurs even in lenses of superior quality.

The objectives manufactured by different opticians resemble each other in most respects, so that an approximative idea of their numbers, powers, and prices may be gathered from the table on page 23, taken from the catalogue of Messrs. Powell & Lealand. Each higher objective is composed of three pairs of lenses, the glasses of every pair or doublet being so combined with each other as to neutralize their respective errors of spherical and chromatic aberration. In objectives of more than $\frac{1}{4}$ of an inch focal length, these doublets are each cemented at suitable distances from the others in the brass tubes which contain them; but in the higher objectives, provision is generally made for altering the distances between the front (anterior, or outside) combination and the other two by means of a screw collar, graduated into degrees, upon its external surface; a lens so arranged is said to be "adjustable to the thickness of the thin glass cover," and possesses the great advantage, that covers of different thickness can be employed without interfering with the defining power.

Immersion lenses were primarily suggested by Amici, but the idea appears to have been first rendered practically useful by M. Nartnack, a distinguished optical instrument-maker of Paris; they are now made by most of the prominent opticians in this country and Europe. The name immersion is applied to them because the constituent doublets are so arranged that the first combination must be *immersed* in distilled water, a drop of which is to be placed upon the covering glass of the object before the body of the instrument is screwed down, so that anything upon the slide is viewed through a stratum of water in-

stead of one of air, as is the case when ordinary or "dry" objectives are employed. The advantages claimed for immersion lenses are that the object is more highly illuminated, because more oblique rays are admitted than would otherwise be refracted so as to pass through the lens, and the "working distance" (or space between the front combination and the thin glass cover) is increased —both of which I have found these lenses to possess in a high degree.

From what has been stated above, it will be readily understood that objectives of the lower powers are manufactured by various opticians with almost equal success, so that, with lenses of $\frac{1}{8}$ inch focus or more, it is often a matter of extreme difficulty and delicacy to choose between them, while, should they differ to any great extent in excellence, microscopists may be found in almost every locality who have practical experience enough to point out their faults. In regard to the higher powers, however, it is much more difficult to form a correct estimate, as few standards of comparison are attainable; and, by way of furnishing some contribution to the literature of the subject, it may not be out of place to detail briefly my own personal experience.

I had an opportunity, not long since, of examining and working for a short time with an Immersion $\frac{1}{10}$, made by Mr. Tolles, of the Boston Optical Works, which performed better than any objective of its focal length that I had previously seen. When accurately focused, the space between the end of the lens and the upper surface of the cover (working distance), although small, was ample, being nearly twice that of the $\frac{1}{25}$; the magnifying power was fully equal to the standard (500 diameters); the definition very superior; the penetrating power, as tested upon a light Podura scale, very good; its field perfectly flat, and the image formed by it entirely free from chro-

matic aberration. It was mounted for use, either Dry or Immersed, and when employed in the latter condition defined well with deeper eye-piecing than any lens I ever saw before, showing, upon my Powell & Lealand's stand, with their No. 4 Eye-piece, the limiting membrane and revolving molecules of the salivary corpuscles with remarkable clearness. The price of such a glass of 160° angle of aperture is $85.00.

A large part of my microscopic work during the past two years has been done with a $\frac{1}{25}$ inch objective, made by Mr. Wm. Wales, of Fort Lee, N. J., and arranged for use either as a Dry or Immersion lens; its defining and penetrating powers are excellent, its field entirely flat, and when "immersed" its magnifying power is fully what it should be, as it amplifies rather more than 1250 diameters, although when used dry, the enlargement of an object viewed through it when most accurately adjusted is not quite so great. Its working distance is very good, allowing the employment of a glass cover $\frac{1}{175}$ of an inch thick, and therefore not so delicate but that it can be readily cleansed in the ordinary way between folds of soft linen. The adjustments for thickness of the covering glass, and for changing it from a "wet" to a "dry" lens, are made by the revolution of the same screw-collar, divided into ten degrees, and so arranged that, if placed at 2°, it gives the best definition of an uncovered object; at 5° the best when used dry with a cover of the thickness mentioned above; and at 8° the best when used as an immersion lens. I have found the stage of Powell & Lealand's stand steady enough, and supplied with horizontal and vertical movements quite sufficiently in the same plane to allow of its satisfactory use; and with the achromatic condenser belonging to my instrument, I can obtain plenty of light, even when the No. 4 eye-piece is used. When I first obtained this glass,—having never

worked with anything above $\frac{1}{8}$,—I was much disappointed that it did not enable me to see more; but after a short time I found that the great trouble was insufficiency of light, and on illuminating the field of my microscope much more highly, I beheld for the first time, to my great delight, the movement of the molecules in the salivary corpuscles, which, although often sought for, had always before escaped my observation. The cost of this lens was $120.00.

Within the last few months I have procured from Messrs. Powell & Lealand, of London, a $\frac{1}{50}$ inch Dry objective, warranted to be equal to the one of which Prof. Beale speaks so highly in his volume on "How to Work with the Microscope." Its penetrating power and its definition, as tested upon the Podura scale and the salivary corpuscles, are excellent; its field is perfectly flat, and its magnifying power, like that of Dr. Beale's, is superior to the nominal capacity, somewhat exceeding 2800 diameters with the lowest eye-piece. (See Fig. 28.) Its working distance is, of course, very small, even with the extremely thin glass covers imported with it for the purpose, and which are so very delicate that they can only be cleansed between two flat surfaces and require the greatest care in handling. In regard to illumination, I find no difficulty in obtaining sufficient light for its use with the No. 1 and No. 2 eye-pieces, by bringing an Argand gas-burner close to the mirror and screwing up the achromatic condenser until nearly in contact with the under surface of the slide, but with the third and fourth eye-pieces the field is too dim to be satisfactory. The fine adjustment for altering the focus and the stage movement work smoothly enough to answer the purpose, and the stand is sufficiently steady to avoid any inconvenient vibration. The price of such a lens, as will be seen by the table on page 23, will be about $300.00, and mine was safely brought to me by the

Americo-European Express from London at a very small additional cost. As far as I can learn, there are at present but two other objectives of this focal length in America—one in the Army Medical Museum at Washington and the other in the possession of Dr. Atkinson, of New York city, the latter, I was informed some time ago, not then in good working order.

Much has been said against the advantages of using these high powers, and their opponents, as for example a writer not long since in the *Quarterly Journal of Microscopical Science*, have even maintained that, notwithstanding their frequent employment, we have yet to hear of any important discovery made by their assistance. Nevertheless, my own opinion is most unequivocally in their favor, and it seems to me that the detection of moving molecules in distended white blood corpuscles* of the cell-walls of the red blood disks in fragments of dried clot,† and of Halford's "peculiar cells" in the blood of animals poisoned by serpents' venom,‡ after they had escaped the attention of such skillful and acute observers as Professors Virchow, Wyman, and Fayrer respectively, can, of course, only be due to the superiority of the lenses I have employed.

Among the essential portions of the microscope it now only remains for me to describe the eye-pieces, whose superior excellence, valuable as it is, is much less important than that of the objectives, because the faults of the former are seen only as they really are, while those of the latter are exaggerated in exact proportion to the power of the eye-pieces employed with them. Most eye-pieces are composed of two achromatic lenses,—the upper, or that

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* Penna. Hospital Reports, 1869, p. 249.

† Am. Jour. of Med. Sciences, July, 1869.

‡ Ibid., April, 1870.

nearer to the eye being called the eye-glass, and the lower, nearer to the field of the instrument, being therefore called the field-glass; these different combinations of lenses of varying convexity, and consequently of varying magnifying power, have received the names of the No. 1, No. 2, etc., but are sometimes spoken of by continental opticians as the A, B, C, etc. eye-piece. The tyro may readily recognize them by remembering that their power is generally inversely as their length; that is, the strongest (technically called deepest), No. 5, or E eye-piece, is the shortest of all, while the weak A, or No. 1, called by opticians the most shallow, is nearly twice as long as any of the rest. The micrometer eye-piece, in its simplest form, consists of an ordinary (Huyghenian) combination, into whose brass mounting tube opposing slits are cut, so that a slip of glass, upon which is ruled a graduated scale of fiftieths or hundredths of an inch, may be passed in, thus enabling the observer to measure the size of objects seen through the slip of glass, the value of each division with any particular objective, and length of microscope body being first ascertained as described in the next chapter. The cobweb micrometer consists of a flat, oblong brass box, arranged permanently between the eye-glass and field-glass of an eye-piece (just as the glass micrometer is temporarily slipped into the simpler form), and containing a light brass frame just fitting the width of the box, and capable of being moved very gradually backward and forward by the action of a screw which works through one of its ends; across this frame, and of course moving with it, is stretched a delicate thread of spider's web, while across, from side to side of the box, is another and parallel thread, of course immovable. To measure any minute object in the field of view, the stationary thread, the movable thread, and the left hand margin of the object are brought exactly in line by turning the micrometer screw

and by adjustment of the slide upon the stage of the microscope, and then, by further revolution of the micrometer screw, the movable thread is slid along to the right until it just touches the right hand edge of the object, when the number of whole turns is read off by means of notches within the box, and the number of hundredths of a turn by the divisions upon the graduated silver circle attached to the screw-head, the value of which divisions having been previously ascertained for each objective, a simple calculation enables one to obtain the diameter of the object desired. In Ramsden's, or the positive eye-piece, sometimes used as a micrometer eye-piece, the field-glass is placed with its convex side upward, instead of the reverse, and so much nearer the eye-glass that the image is formed beneath it in place of between the two lenses; its disadvantage is want of flatness of field. Kellner's Orthoscopic Achromatic Eye-piece, according to Carpenter on the Microscope (4th edition, London, 1868, p. 26), is so constructed that "the field-glass, which is a double convex lens, is placed in the focus of the eye-glass without the interposition of a diaphragm, and the eye-glass is an achromatic combination of a plain concave of flint, with a double convex of crown, which is slightly under-corrected, so as to neutralize the over-correction given to the objectives that are ordinarily used with the Huyghenian eye-pieces." It gives a large, flat, well-illuminated field, but somewhat impairs the defining power. In default of a variety of eye-pieces, the student may nearly double the power of the one he has by screwing off the field-glass and using the eye-glass alone, or by adapting a roll of pasteboard to the body of his microscope, in the manner of a draw-tube, so as to lengthen the distance between the eye-piece and objective.

The adaptation of Prof. Wheatstone's invention of the stereoscope to the microscope, in the form of the binoc-

ular, has enabled us, by the combination of two dissimilar images of an object simultaneously impressed upon the two retinæ, to obtain that accurate perception of solidity which observation with a single eye fails to give. In this instrument, by means of an arrangement of prisms placed just above the objective, that combination is, as it were, bisected, and two images formed on the two opposite sides of the lens are refracted upward through separate tubes, one to each eye respectively; when the pencils of rays which form these images are crossed, so as to reach the eye on the opposite side from that whence they proceed, the picture formed by them is in relief, or stereoscopic, while, if allowed to enter the eyes without this decussation, so to speak (and, by-the-way, may this not give some clue to the design of the decussation of the pyramids and of the optic nerves?), the picture appears excavated, or, as it is called, pseudoscopic. This improvement can be adapted to first-class microscopes of the ordinary form, at an expense of about $100.00, by most of the leading opticians; and Messrs. J. W. Queen & Co. have recently imported a Student's Binocular, made by Collins, of London, which they furnish complete at about $50.00.

CHAPTER II.

INSTRUMENTS, APPARATUS, AND MANIPULATIONS.

THE ingenuity of microscope-makers has led to the invention of an almost infinite variety of additional apparatus for the purpose of saving labor, time, and trouble, at the cost, of course, of increased pecuniary outlay; but as the microscopist who makes the study enough of a specialty to render it worth while for him to procure these luxuries, will doubtless obtain also much more pretentious and elaborate treatises upon the subject than mine, I shall but briefly allude to the high-priced accessories, and describe in detail only those few which are indispensable and those which can be arranged by an operator himself at a trifling cost; assuring the student that the trouble thus expended in adjusting home-made apparatus to the instrument will be amply repaid by the greater familiarity with the practical working of the microscope which he will thus attain.

Among materials of primary importance, are to be procured glass slides for the examination and mounting of objects; these should be of plate glass, as free as possible from stains or scratches, and cut to the exact standard size of three inches long by an inch wide, in order to fit into cabinets and object-holders. They may be obtained of dealers in Philadelphia, and I suppose elsewhere, at 60 cents per dozen for those with ground edges, and 25 cents per dozen for those whose edges are unground, the only disadvantage of the latter being an occasional cut from careless handling. Until the student commences to mount

specimens for permanent preservation, one dozen will be quite enough for him to purchase; indeed, he may save himself some mortifying blunders by using but a single slide while it lasts, and so becoming familiar with all its microscopic flaws and scratches, which I have known to be mistaken for epithelial cells, fibrin filaments, and other important abnormal ingredients of urine, blood, sputum, milk, pus, etc.

Thin glass covers for placing over the object as displayed upon the slide are, of course, absolutely necessary, and may be procured in the form of either circles or squares, the former costing forty and the latter thirty cents per dozen. For ordinary examinations merely, the squares answer every purpose; but for mounting, the circles are more convenient, and present a much neater appearance as finished. When soiled, the covers are best cleaned by dipping them in water and then holding them by the opposite edges between the left finger and thumb, while they are carefully but firmly rubbed dry and bright with a soft linen or muslin cloth (not so old as to shed lint), spread over the corresponding digits of the right hand. For cleaning the very thin glass required for covering objects examined with the $\frac{1}{25}$ and $\frac{1}{50}$, I have generally found it sufficient to lay a soft rag upon the table, place the cover, after dipping in water, upon it, and then, folding the cloth over, rub the glass gently between the two layers of muslin, turning it if necessary, until cleansed; or the method advised by Prof. Beale, of preparing two flat disks of wood, covered with buckskin, and polishing the thin glass between them, may be adopted. I have obtained glass thin enough for use with the $\frac{1}{25}$ inch objective from the Messrs. Grunow, of New York, but for my $\frac{1}{50}$, was obliged to import some of exceeding tenuity from Powell & Lealand, of London. My experience with thin laminæ of mica, recommended by some authorities, has not

been very satisfactory, for, besides the tendency of this substitute to become scratched very soon, I have not found the definition of objects seen through it equal to that obtained when glass was employed. With low powers of the microscope, that is, objectives of more than $\frac{1}{4}$ of an inch focus, moderate differences in the thickness of the glass covers are unimportant and may be quite ignored, but with the higher powers, delicate adjustment is necessary in accordance with the thickness of the covering lamina, as will be described under the head of Manipulations.

Small needles, mounted in light wooden handles, are required in arranging the tissues of morbid growths, etc. for examination with the microscope; they are readily prepared by making a wooden cylinder, about the size of a small lead-pencil, forcing the point of a No. 6 needle, held with a pair of pincers, into the end, so as to make a puncture about half an inch deep in the axis of the stick, and then reversing the needle, imbedding its eye to about the same depth in this aperture. These little instruments are invaluable in "teasing" out small fragments of healthy structure or of morbid growths, as described in Chapter XV.

Forceps and scalpels for dissecting off minute fragments of tissues for microscopic examination may be such as almost every medical man possesses in his pocket- and dissecting-case, and, therefore, require no special description. Very satisfactory thin sections can often be cut with a sharp razor.

Conical glasses of about five ounces capacity are very useful in examinations of urinary deposits. They should be selected with a cavity, rounded at the apex of the cone, and not tapering to a point, because then they are very difficult to keep clean and so lead to lamentable errors. Comparative observations on the bulk of sediments are much facilitated by having these vessels graduated, as

can readily be done by desiring a druggist to measure into them one, two, four, and eight fluidrachms, and four fluidounces of water, marking the level of the liquid, after each portion is poured in, with a file upon the glass.

Tube pipettes should be made by the operator himself by drawing off to a point, in the flame of an alcohol lamp or gas-burner, pieces of glass tube 12 inches long and about $\frac{3}{16}$ of an inch in external diameter, and then breaking off the tips so as to leave apertures large enough to admit a pin. For ordinary use the instrument-makers' pipettes with bulbs blown upon their stems have no advantage, and are much more fragile and expensive than those just recommended. Small glass tubes of the kind referred to may be cut to any length by making a little notch in one side with a file (as that on the nail-blade of a common pocket-knife), and then sharply bending the tube away from the notch, at the same time pulling the two ends strongly apart; in this way an exact transverse fracture may generally be secured; but if projections remain which would interfere with the complete closure of the pipette by the finger, they may be removed by light rasping touches of the flat surface of the file. Any unpracticed person will be surprised, on trial, at the ease with which glass tubing may be manipulated as above described.

Among the few reagents that are necessary, acetic acid is one of the most important, since its effect upon organic cells, in rendering the nucleus more distinct, is often of great value; it should be of the strength denominated by apothecaries No. 8 (because when mixed with seven times its bulk of water it corresponds to vinegar in acidity), and is best kept in a test-bottle with an elongated conical stopper, or, what answers the same purpose, in a vial having inserted in the lower part of its cork a short piece of glass rod (or of glass tube drawn off to a point and

sealed), by which a drop of the reagent can at any moment be applied where required.

Aqueous solution of iodine is sometimes very useful in rendering delicate cell membranes, the tube-casts of Bright's disease, etc. more distinct under the microscope. A convenient preparation is made by adding ten drops of the Liquor Iodinii Comp., U. S. P., to a fluidounce of water, but occasionally a mixture of three or four times that strength will be found useful.

Solution of aniline red gives a beautiful purple tint to most organic cells, and especially their nuclear or "germinal" matter. It should be prepared by dissolving one grain of the greenish "Fuchsine dye" in an ounce of water. The solution of this substance may be greatly accelerated by the addition of acetic acid; but, as for some purposes a neutral reagent is advantageous, I prefer to dissolve it by mere agitation.

A preparation I have found very useful is a simple or carbolated syrup, of the specific gravity of blood serum (1028), made by dissolving about 40 grains of sugar in an ounce of water, and prevented from undergoing decomposition by adding five drops of crystallizable carbolic acid; in this liquid cancer cells, blood corpuscles, etc. retain their shape and general appearance almost as if examined in the fluids of the body which normally bathe them, and therefore, of course, much more correct views of their nature may be obtained. A dilute glycerin of similar specific gravity, made by mixing three and a half fluidrachms of "Bower's" glycerin with four ounces of water, is preferable, as being free from any tendency to decomposition.

For chemical processes intimately associated with microscopical research, the student will require half a dozen test-tubes with their rack, an alcohol lamp, and the usual reagents,—among which are nitric acid, for detecting

albumen; solutions of sulphate of copper and of caustic potash (or Barreswil's test*), for examining urine when, from any cause, as the presence of torula in abundance, the existence of sugar from diabetes is suspected; also blue and red litmus-papers, for testing the reaction of urine, vomit, etc. He should likewise be provided with a small capsule or evaporating dish of about two ounces capacity, and a supply of solution of caustic soda, made with five drachms of the caustic alkali of the shops to one pint of pure water, for the purpose of testing sputum, as directed in Chapter IX. A urinometer and accompanying jar for testing the specific gravity of the urine, will often be found very useful.

Among the pieces of accessory apparatus which, without being absolutely indispensable, are yet extremely important, is the camera lucida, either in the form of a glass prism or of the steel disk of Soemmering, by either of which, when properly adjusted to the eye-piece of the microscope, with its body placed horizontally, images of objects on the field are reflected perpendicularly downward, and if received upon white paper, may readily be traced, in outline, with a pencil, of almost any amplification required.

The stage micrometer is nothing more than a slip of glass, upon which are ruled a number of lines, some $\frac{1}{100}$ and some $\frac{1}{1000}$ of an inch apart; it is used to determine the exact amplifying power of the various lenses combined with different eye-pieces, and for measuring the magnitude of different objects as magnified upon the stage,

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* Composed of	Cream of tartar . . .	96 grains.
	Crystallized carbonate of soda .	96 "
	Sulphate of copper . . .	32 "
	Caustic potash	64 "
	Water	2 fluidounces.

in the manner described under the head of Manipulations. In the absence of such a standard, the red corpuscles of healthy blood, dried upon a slide, afford an excellent natural substitute. They measure on an average about $\frac{1}{3500}$ of an inch in diameter.

Under the higher powers it is often difficult to find a particular object mounted upon a slide without some mechanical assistance, and I have often seen much valuable time wasted in a vain endeavor to hit upon a special Diatom or other test object which the microscopist desired to exhibit.

When the microscope is provided with the stage movement, an excellent method of avoiding this inconvenience is to divide the brass-work in which the stage traverses by small scratches upon the edges of the grooves $\frac{1}{50}$ of an inch apart. By counting the number of these divisions to the right of and above some standard point, and noting them upon the label of the specimen, it is obviously easy to replace the slide at any future time in the exact position beneath the lenses which it occupied when the required object was in the field of view. Maltwood's Finder, a very simple and ingenious contrivance, for accomplishing the same end, consists of the photograph of 625 minute squares, and in each of these (except the center one) are placed two different numbers, which, if noted, enable the observer to bring that particular square beneath the objective at any future time, when, of course, if the finder be removed and replaced by a mounted slide, any object upon that which has been previously determined to occupy the same relative position to the lower left-hand corner of the slide will appear in the field of view.

For cutting thin sections, either of morbid growths or healthy tissues, Valentine's double-bladed knife is a valuable instrument in the hands of one accustomed to its use; it consists of two parallel blades, so adjusted that

their distance apart can be accurately regulated by means of a screw and catch, and yet capable of easy separation, for the removal of the section cut, or for the purpose of cleansing the instrument. By skilled operators, beautiful sections may be obtained; but beginners often find at first that they can prepare no more satisfactory specimens with it than they could with a sharp scalpel and needles; at least such, I confess, was my own experience.

Small scissors, curved upon the flat, similar to those employed in ophthalmic surgery, are often useful in the preparation of thin sections from soft tissues; the attenuated edge of a minute fragment clipped out of the liver, kidney, etc. sometimes affording a magnificent view of the minute structure.

For cutting thin sections of hard tissues, such as bone, horn, etc., delicate saws are required, and the specimen must subsequently be ground down and polished upon hones of different degrees of fineness.

Glass dishes or gutta-percha troughs are necessary when dissection of a specimen under water is to be carried on, an operation which is much facilitated by pinning the specimen to a flat cork, imbedded in a disk of lead, to keep it beneath the surface of the fluid.

The compressorium, or its improved form the Lever compressor, is highly recommended by Prof. Beale for demonstrating the exact relation existing between the structural elements of tissue. It enables the operator to apply pressure, graduated by means of a screw, to a specimen placed between the two glasses until the object is reduced to an extreme degree of tenuity.

The process of minutely injecting morbid tissues is so rarely employed by any except professed and experienced microscopists, that a brief reference to its modus operandi is alone required in this place. An artery of considerable size is to be selected, into which one of the separate inject-

ing pipes is to be inserted and tied securely, but not so firmly as to risk cutting through the arterial coats; the other blood-vessels, except one or two of the veins, are to be ligated, and arrangements made to stop, by means of Bull's nose forceps, such vessels as may have escaped such closure. The injecting fluid, which may be either the Prussian blue or carmine mixture, so highly lauded by Prof. Beale, being already prepared, the syringe is filled with it, the nozzle inserted in the pipe already tied in the mouth of the artery (great care being taken to avoid the passage of any air into the vessel), and the piston very slowly and gradually forced down, so as to throw the liquid into the tumor. After allowing the specimen to remain undisturbed a sufficient length of time, for the non-fluid portion of the injection to be absorbed, incisions may be made into the substance of the tissue, and thin sections cut from portions, which, when examined under a magnifying-glass or under a low power, appear to be well filled with the coloring matter. It is rare to find that the injection has been equally successful in all parts of a morbid growth; and the tyro, who feels almost disheartened at his own failures when contemplating the exquisite beauty with which every delicate arterial twig is sometimes brought into view, may find some consolation in knowing that the splendidly injected section he admires is perhaps one of a fortunate few which could alone be obtained by quite a skillful operator from some large and carefully prepared specimens.

The branch of the microscopist's art which relates to the mounting of specimens for permanent preservation, important as it is, does not fall sufficiently within the present scope of this work to justify any extended exposition here. As, however, some of my readers who may happen to be without any more elaborate treatise upon the subject will perhaps feel desirous of preserving some remarkable speci-

mens they chance to meet with, for future study, I will briefly describe a few of the processes required.

Mounting objects in the dry way is a method particularly adapted to the preparation of blood corpuscles; to the various species of acari, as the itch insect; specimens showing the achorion Schönleinii, etc. The object is simply to be deposited upon an ordinary glass slide in a suitable position, a thin glass cover laid gently upon it, and a piece of colored glazed paper, perforated by a circular opening somewhat smaller than the glass cover, and coated on its under side with mucilage, pressed down over this in such a way as to hold the cover firmly in its place, and at the same time quite exclude dust and dirt from the specimen.

For preserving objects in the wet way, that is, in liquid, it is probable that none of the numerous solutions which have been proposed are of such general utility as glycerin, and I would strongly advise the student to commence his labors as a mounter of specimens with it as a preservative fluid. For this purpose the thin section of any structure, as for example a carcinomatous growth, should be placed in a watch-glass, filled with mixture of one part of pure water to two of the best glycerin, and allowed to soak for two hours. It is then to be removed upon a mounted needle, or between a delicate pair of forceps, to another watch-glass containing pure glycerin, in which it should be allowed to remain, carefully protected from dust by a bell-glass cover, for three or four days, when it will be found to occupy the volume it did when fresh, having recovered entirely from the shrinking which primarily takes place. If it is desired to exhibit the nuclei of a tissue rich in cells, the strong glycerin may be slightly acidulated by adding a drop of the No. 8 acetic acid to two drachms of the liquid; or should it be deemed desirable to stain the "germinal matter," the section should be first of all im-

mersed in Dr. Beale's carmine solution* until sufficiently colored, great care being used to avoid giving it too deep a tint. After remaining a sufficient length of time in the strong glycerin, the specimen may be transferred to a glass slide, properly arranged, so as to display to the best advantage, by means of the mounted needles, one or two drops of glycerin added, and a thin glass cover applied, first by one edge, and then its opposite margin gradually lowered down upon the point of the needle (using every precaution to get rid of all air-bubbles) until the cover is laid flat upon the slide with only the specimen surrounded with a layer of glycerin, the excess (if unfortunately there is any) of which is to be wiped off with a soft cloth, slightly moistened. The edges of the cover should now be touched in three places with cement, and when these become dry, the preparation is ready for sealing hermetically by applying over the edges of the cover a thick coating of cement, which may be gold size, solution of gutta-percha in chloroform, sealing-wax varnish, etc., or, what I have found very satisfactory, a mixture sometimes called "Hunt's Cement," extensively used in the Army Medical Museum at Washington. It is there, as I am very kindly informed by Col. J. J. Woodward, prepared by evaporating Canada balsam to a solid consistence, dis-

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* "Carmine	10 grains.
Strong liquor ammoniæ . . .	½ drachm.
Price's glycerin	2 ounces.
Distilled water	2 ounces.
Alcohol (?)	½ ounce.

Boil the carmine and liquor ammoniæ (liq. ammon., F.F.F.) for a few seconds, let stand an hour, add the glycerin (Bower's will answer) and water, filter, allow to settle, and pour off the clear supernatant liquid for use." Sections should be immersed in this for from half an hour to twelve hours, according to their softness and succulency; they have the great advantage of not fading after being mounted, as readily as if stained with aniline.

solving it in an equal bulk of benzole, and then thickening it to about the density of cream, with white-lead or zinc, ground in oil. A formula similar to this, except in substituting chloroform for benzole as a solvent, was first introduced into general use here by Dr. J. Gibbons Hunt, of this city, who recommended it at the meeting of the Biological and Microscopical Section of the Academy of Natural Sciences of Philadelphia, held April 19, 1869. (See Transactions.) It is furnished by Messrs. J. W. Queen & Co. at 50 cents per bottle, containing about an ounce.

The preparation of gold and silver stainings, after the methods of Cohnheim and Von Recklinhausen, for the purpose of exhibiting the stomata in the walls of blood-vessels, the parietal nuclei of capillaries, and the fixed corpuscles and ultimate nerve-fibers of the cornea, etc., is accomplished by soaking the perfectly fresh tissues from one to ten minutes in half per cent. solutions of chloride of gold or nitrate of silver, washing in pure water, and exposing to diffused daylight for twenty-four hours, and then mounting in glycerin. (See a very instructive paper by Wm. F. Norris, M.D., in the Transactions of the Biological and Microscopical Section of the Academy of Natural Sciences, *Medical Times*, Philadelphia, Oct. 1870.)

Having thus described—too briefly, perhaps, in some instances—the most important forms of the microscope and its accessory apparatus, I shall now attempt to introduce the student to the methods of employing them in the practice of medical microscopy, and as this use can be doubtless best illustrated by describing the steps of an actual examination, I propose to narrate in detail all the minutiæ connected with investigating a drop of saliva, selecting that as a secretion which can always be readily obtained, and one which affords good test objects for both the high and low powers of the microscope.

Supposing, now, that the student, *a complete tyro* in the art, has procured a Woodward's microscope (or some other of the cheaper forms of the instrument), half a dozen glass slides, as many thin glass covers, and a bottle of aniline solution,—how shall he go to work at putting his treasures to practical use? In the first place, select a firm, steady table, stationed before a window, preferably with a northern exposure (as being always free from direct sunlight), and seating yourself so as to have your left shoulder toward the window, remove the instrument from its case, and place it before you in about the position shown in Fig. 1, inclining it at such an angle that the eye conveniently adapts itself to the top of the tube without stooping over and so contracting your chest; then screw on the longer lens (No. 1) to the lower end of the microscope body, and slip the eye-piece, if not already there, into the opening of the upper extremity, turn the revolving diaphragm until the next to the smallest hole is opposite the center of the aperture of the stage and adjust the mirror beneath at such an angle that the light from the window falling upon it is reflected upward through the hole in the diaphragm, and the glasses occupying each extremity of the microscope body, into the eye applied closely to the eye-glass of the eye-piece.

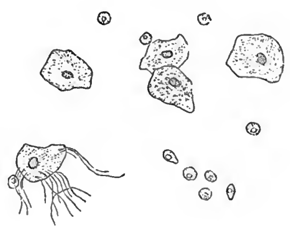
Next proceed to prepare an object for examination by accumulating a little saliva in the mouth (rubbing the tongue against the teeth pretty strongly to scrape off some of the epithelial cells), and letting a drop fall from the tip of the tongue upon the middle of a clean glass slide; cover it by laying gently upon it a square (or circle) of thin glass, and absorb the surplus fluid, by bringing in close contact with it the corner of a soft linen or muslin rag, then place a very small drop of the aniline solution (or of tincture of iodine) at the lower right-hand

angle of the thin glass cover, so that a little of it may run in between the two glasses, and thus tint the saliva and its contents at that part a crimson or yellowish-brown, according as the former or latter reagent has been employed to render the epithelium, etc. more distinct.

Now place the slide thus prepared upon the stage, raising up the spring clips, and slipping it under them, so that by their pressure they may prevent it from becoming displaced; push it down beneath the springs until the corner of the cover to which aniline has been applied occupies the middle of the little circle of light allowed by the diaphragm to pass up from the mirror, then slide the body of the microscope downward in the tube which carries it, until the objective, at its lower extremity, is within about one-eighth of an inch of the surface of the glass cover (this you can best determine by bringing the eye down to a level with the stage and looking at the window between the lens and the slide); then, looking through the eye-piece at the top of the body, raise the latter very slowly by screwing it round, at the same time that you draw it *upward* gently, until the corner of the cover (recognized by its appearing like the *upper left-hand* angle—because apparently inverted by the microscope—of a slab of glass such as is used for skylights in floors) comes into view; when you may *focus* it,—that is, raise and lower the lenses until you find, by repeated trials, the exact distance at which you can see it most plainly, by means of the fine adjustment, turning the milled head to the right or to the left, according as you find necessary to increase or decrease the space between the objective and the object; you will soon discover, on attentively studying this corner of the thin glass, that (speaking of the field as if it were a map) the little particles of dust, etc. upon the glass to the north, northwest, and west of the angle require the microscope body to be depressed farther than those toward the

southeast of the same point; this is due to the thickness of the covering glass. After adjusting the focus so that some little particle upon the slide itself is plainly visible, take hold of the ends of the slide with the fingers and thumbs, and slip it very slowly in a diagonal direction, so that the angle of the cover appears, through the microscope, to move toward the northwest part of the field; continue this motion as far as the middle of the cover, and then reverse the movement (with such slight variation as will avoid repassing over the same surface), and so proceed until you find a body resembling the larger of those depicted in Fig. 4, or until you are satisfied no such object exists upon the slide, when it may be laid away and a new one prepared. Presuming, however, that you are successful in discovering such a body as that figured (an epithelial cell from the mucous membrane lining the mouth), it will not be found quite distinct when examined at the focal distance for particles seen upon uncovered portions of the slide, so that the body of the instrument must be raised slightly by means of the fine adjustment until its outlines are clear and sharp, and the nucleus—the dark-red oval mass situated near its center—is bright and well defined. Then change the objective (screwing on the little one), bring down the lens to about $\frac{1}{30}$ of an inch from the thin cover, and slowly raise it as before, until the cell is exactly in focus, moving the slide, if necessary, to bring it to the middle of the field, and after it has been thoroughly examined, other similar struct-

Fig. 4.



Squamous epithelial cells, salivary corpuscles, and filaments of fungi in a drop of saliva. Magnified 100 diameters.

ures less strongly tinted, and then still others (toward the opposite corner of the cover), in a normal condition, are to be carefully studied until you become quite familiar with that important histological element, the *Squamous Epithelial cell.*

Since we all perform any work to which we are unaccustomed, more efficiently when we know why each step of a prescribed process is taken, and wherefore a seemingly similar operation is less advantageous, I will endeavor to give a species of commentary explaining the above directions. First, then, a firm, steady table is to be chosen as a support for the microscope, not merely because less likely to be overturned, but because the vibrations communicated from surrounding bodies might otherwise cause objects upon the slide to shake or "dance," so that they could with difficulty be examined; the microscope is to be so placed that the light falls upon its mirror from the left, because on that side the right hand manipulating the object upon the stage does not obscure the light; some microscopists prefer to sit in front of a window, but such a position is not quite so convenient when very oblique illumination is to be employed. Working by gas- or lamplight is much more trying to the eyes, but except on that account I have not found it objectionable, and have often employed such illumination for three or four hours of an evening without, as yet, apparent injury; the yellow tint of the flame may be corrected by passing it through a shade of light-blue glass, by wearing blue spectacles, or by having a blue glass (night) cap for the microscope. Before screwing on the lenses and inserting the eye-piece, you should always see that no little particles of dirt or fibers of cotton adhere to the glass,—should they do so, breathe gently upon the surface and wipe clean with a soft rag or piece of buckskin. Particles of dust upon the eyepiece, which often appear as objects upon the field of view,

may be recognized by revolving as the eye-piece is turned round in its socket. The second small hole of the diaphragm is advised because, while admitting sufficient light, it does not render the field too bright to see faint markings; but the other apertures should be tried in succession, so as to become familiar with the results of different illumination; sometimes there is a little difficulty in throwing the light from the mirror up the tube, but it is soon overcome by practice.

In preparing a specimen of saliva, it is well to make sure that you have something besides transparent liquid by observing whether any little faint, grayish particles, just visible to the naked eye when the slide is held obliquely, are to be seen beneath the thin glass; if not, it is better to wash off the slide and prepare another specimen; of course the particles detected by the unassisted vision are not single epithelial cells, but may be aggregations of them, or what is more probable, tiny fragments of food, to which both epithelial cells and salivary corpuscles are often attached. The excess of saliva should be absorbed from the margin of the thin glass, simply because if the latter merely floats lightly upon a drop of fluid buoyed up beyond capillary attraction's sphere of action, it is apt to glide off when the slide is inclined to place it on the microscope stage; at the same time care must be taken not to press upon the cover with the cloth, or to push it along while absorbing the moisture, lest the delicate structures in the saliva be crushed or rolled together, and so rendered indistinguishable. The addition of aniline or iodine solution is only intended to render the epithelial cells more distinct, to a novice, and prevent their being overlooked; of the two liquids, aniline gives the brightest tint, but iodine (see page 37) does very well; or the experiment *may* be first tried without any coloring matter, if neither of those mentioned is at hand.

In putting the slide upon the stage, be careful not to push it against the spring clips so that they will disarrange the cover, as sometimes occurs; the pressure of these springs should be just sufficient to prevent the slide from slipping out of place, and yet allow of its being freely moved by the fingers as desired. The lower right-hand corner of the square cover (no better than any other corner, but chosen to render the subsequent directions more explicit), or the corresponding edge of a thin glass circle, is selected merely as being a well-defined, always present object, and therefore a suitable guide to the adjustment of the focus, that great difficulty with beginners. The method advised of bringing the objective close to the thin cover, but just not touching, and then raising it till you find the focus, is the one I generally resort to with high powers, and consider it far safer for both objective and specimen than the opposite plan of seeking for the focus from above by depressing the microscope body until the object comes clearly into view; I have seen a valuable $\frac{1}{12}$ inch lens ruined by being screwed down against the glass slide. "Focusing" an object by means of the fine adjustment is nothing but a series of experiments (performed by turning the knob back of the tube), the aim of which is to decide whether the object to be examined can be seen most distinctly when the lenses are the hundredth or the thousandth of an inch nearer to or farther from it. The purpose of the coarse adjustment (made in this instrument by sliding the body in the tube which carries it) is to regulate the distance within perhaps the $\frac{1}{50}$ of an inch, after which the fine adjustment is brought into play to place the object exactly in focus. What is called Transitional focusing consists in a rapid alteration, by quick turns of the screw, of the distance between objective and object, causing the latter to be at one moment just within, and at another just outside, the point of clearest definition; it is often of great assist-

ance in detecting difficult details of structure. In seeking to bring atoms of dust upon the slide into view, the student may be puzzled for a moment by finding that numerous particles are to be seen to the southeast of the angular corner, while the north, northwest, and west parts of the field are perfectly transparent; or he may find nothing visible in the field but the rectangular dark margins of the cover showing their peculiar conchoidal fracture. He must not, however, conclude in the first case that there is no dust upon the slide; nor in the second, that there is none upon either slide or cover; for, by simply depressing the body of the microscope, he will probably discover some minute fragments of dirt or scratches upon the glass to the northwest of the angle, although, if the directions are strictly observed, he will not be apt to meet with such a difficulty, but will perceive (should the slide be properly placed), as he raises the tube of the instrument, the rectangular corner of the glass cover at first cloudy and indistinct, but gradually becoming more sharply defined, until particles or scratches begin to appear in a northwest direction from it. The reason that dust upon the slide is best seen with a longer focus when covered with thin glass than when uncovered, is that the rays of light reaching the lens with a greater divergence after traversing strata of glass and of air than after passing through air alone, require an increase of the focal distance to cut off the too divergent rays, and so produce distinct vision.

If, in spite of these prolix instructions, you fail, firstly, to detect a corner of the thin glass cover, it is probably because it is not exactly in the field, and to remedy this you must arrange the objective as before, about the $\frac{1}{8}$ of an inch from the upper surface of the cover, and change the place of the slide a little, at the same time that you look through the microscope, until you perceive, by the sudden diminution of the light, that some opaque substance is

below the lens; on focusing, by raising the body of the instrument, you will either find the margin of the cover or some object upon the slide which will enable you to adjust the instrument to its focal distance; when, by moving the slide about in various directions, you will soon bring the edge of the cover into view, and following it along, come to the sought-for corner. Secondly, after finding this angle of the thin glass, you may have some difficulty in detecting any little particles of dust as guides to the proper focus of objects on the slide; in which event raise up the body of the microscope, remove the slide, sprinkle on the tinted corner a little dust, common flour, or any other fine powder, and having replaced it upon the stage, proceed as at first directed. Thirdly, the slide which you have prepared may happen to contain no epithelial cells, in which case wash it off, wipe the glasses, and prepare another specimen, which can hardly be equally barren. You must not suppose, as some are inclined to do, that reading over any instructions whatsoever, will enable one to become a good observer, for there is no more a royal road to microscopy than to any other branch of learning, and it is only as you are willing to try and try and try again, carefully and patiently, that you can hope to become skillful in this most delightful occupation.

Having become familiar in the manner described above with the scalelike epithelial cell, first in its tinted, and afterward in its normal conditions, as seen with a power of 350 diameters, the young microscopist should render himself intimately acquainted with the other ingredients of the saliva, by preparing a fresh slide without the addition of any coloring material, and having brought its surface into focus, and found an epithelial scale, should carefully examine the rest of the field for some small nucleated granular bodies, a little larger than the nuclei of the epithelium, but differing from them in being spherical instead of

oval (see Fig. 4); if, however, none are to be seen, change the field by moving the slide very slowly, as suggested above, until one or more are detected. These bodies are the salivary corpuscles, formerly supposed to be peculiar to the saliva, but which I have shown to be simply distended white blood globules. (See Chap. VIII.; also Fig. 10.) They constitute the best convenient test for objectives, ranging in magnifying powers from 200 to 1200 diameters, with which I am acquainted. If, with your Woodward's microscope, you can plainly see the one, two, or three nuclei of an untinted corpuscle, you may feel well satisfied with its performance; and should you be able to detect the motion of the molecules it contains (see Chap. VIII.), you have been fortunate enough to obtain a superior instrument.

In searching for the salivary corpuscles, you may perhaps observe some very faintly outlined, rounded, or irregular masses, occupying from a small part to a whole field, or even more, made up of extremely delicate threads, some of which, on close scrutiny, will be seen to have a more or less active vibrating motion; these are filaments of the Leptothrix buccalis of Ch. Robin (by Hallier and others believed to be one form of Penicillium), and are best studied by removing a minute portion of the tartar which accumulates between the teeth when it cannot be reached by the brush, and examining it in saliva; the filaments sometimes grow from old epithelial cells, as shown in Fig. 4. It is also important to become familiar with the appearance of air bubbles beneath the thin glass, which I have known to be mistaken by novices for some extraordinary structures; when small, they are usually circular (see Fig. 14), and even if large, their margins are generally composed of segments of curves; if you find difficulty in detecting them, move the slide so that some portion of the upper edge of the cover is in the field, and wait a few minutes until the fluid begins to dry away, when the air will enter to supply

its place and afford you an excellent opportunity to study the characters of its bubbles. After becoming acquainted with these, you should compare them very carefully with oil globules (which they sometimes strongly resemble) by examining a drop of milk or by rubbing a little oil and water together (moving a thin glass cover backward and forward over such a mixture until it becomes milky), when you will find not only oil globules and air bubbles, but also globes of oil containing air, all of which will furnish you very profitable objects of study. If you have any difficulty in distinguishing them, add a little aniline solution, by which the oil will become more or less tinted, while the air bubbles, of course, will be left colorless in the crimson fluid which surrounds them.

There are many other elements more or less accidental, which you may happen to meet with in saliva, all worthy of attentive examination, as most of them may occur in the various secretions of the human system, and each present to you a separate enigma; such, for example, as portions of food, among the most common of which are granules of wheat, rice, and potato starch, fibers of celery, spinach, and cabbage, and fragments of muscle (see Fig. 14), elastic tissue, etc. from the different domestic animals; or, again, particles from clothing, such as filaments of silk, cotton, or wool, hairs of various animals (see Fig. 20), pollen grains, animalcula, ova, and spores of a multitude of minute organisms which constantly float in the atmosphere (see Prof. Tyndall's late experiments), and being inhaled at every breath, are frequently deposited upon all parts of the respiratory passages; with an abundance of other objects too numerous to mention, and only to be learned by faithful and persevering study.

Modifications of the method for examining a slide of saliva as directed above, which are requisite when the student has the use of a more complete and expensive in-

strument, are neither very great nor very numerous, the main principles of construction being similar in almost all compound achromatic microscopes. If, for example, you can command a Zentmayer's Grand American Microscope (Fig. 3), you may proceed with it, placed as above directed, using the concave mirror to reflect the light, screwing on at first the $1\frac{1}{2}$ inch objective to the lower extremity of the microscope body and slipping the No. 1 eye-piece into its upper end. Then lay the prepared slide upon the stage, by means of the milled heads just below it, bring the south-east corner of the cover opposite the circle of light from the diaphragm, and having depressed the objective to within $\frac{1}{4}$ of an inch (instead of $\frac{1}{8}$) of the surface of the cover by means of the coarse adjustment, slowly raise it again until the angle of the thin glass comes in sight, when, if necessary, the stage should be moved by means of its adjusting screws until that particular corner occupies the center of the field of view, after which you may change the eye-piece for No. 3 (giving a power of about 100 diameters), and proceed to look up an epithelial cell as before suggested. In order to study the cell satisfactorily, however, you must examine it more highly magnified, to accomplish which, bring it to the exact center of the field, unscrew the $1\frac{1}{2}$ inch objective, and remove the No. 3 eye-piece, replacing them by the $\frac{1}{5}$ inch and the No. 1 respectively, depress the microscope body until the objective is within $\frac{1}{20}$ of an inch of the thin glass cover, and then gradually elevate the lens until you obtain the right focus; if the epithelial cell is not visible, move the stage (by turning its milled heads) north, south, east, and west, until you find it or some other equally satisfactory, which you may study under magnifying powers of about 500 and 700, by exchanging the eye-piece for No. 2 or No. 3, without disturbing the objective. The chief advantages (beside those derived from superiority of lenses) being, you ob-

serve, the much greater ease with which you will find any required object under a lower power, and by the aid of the stage movement, coupled with the far better illumination from the large mirror.

If, after a good deal of practice with the lower powers, —that is, those of more than $\frac{1}{8}$ of an inch focal length,— the microscopist determines to procure a still higher objective, he will very probably, as intimated above, be at first disappointed with its performance ; but gradually (speaking from my own experience, at least) one object after another will dawn upon him, until before long he finds himself most bountifully repaid for all his expenditure of time and money ; in fact, I think it becomes daily more and more evident that it is only with such very powerful lenses that we can hope to penetrate some of the most important secrets of life, disease, and death which have hitherto eluded our best efforts. I have found the management of the $\frac{1}{25}$ and $\frac{1}{50}$ beset with no especial difficulties, only requiring a much higher degree of the same caution, gentleness, and patience necessary in handling the $\frac{1}{5}$ inch objective. In the first place, the glass covers must be much thinner, averaging about $\frac{1}{200}$ for the $\frac{1}{25}$, and $\frac{1}{500}$ for the $\frac{1}{50}$, and these must be handled, of course, with the greatest delicacy ; again, although sections of kidney, liver, etc. may be readily cut of sufficient tenuity for examination with the former of those objectives, it is no easy matter to prepare them for the latter. The achromatic condenser for increasing the light upon the object is absolutely necessary ; and when using the $\frac{1}{50}$, even the Argand burner, if gas illumination is employed, must be brought very close to the mirror. Instead of merely bringing the front lens of the combination within $\frac{1}{20}$ of an inch of the cover, it must be depressed until the most slender line of light (reflected, say, from a piece of white paper or muslin, held on a level with the eye, on the op-

posite side of the stage), not thicker than the thinnest tissue-paper, is visible between them. Great care must be taken to focus with only the lightest touches upon the fine adjustment screw, and it is a good plan to begin your observations with examining a specimen of fluid blood, since, in that case, if in a moment of forgetfulness you screw down the objective in contact with the glass, your attention is called to the fact before any damage is done by seeing the globules rush madly across the field until lost to view beyond its margin. And lastly, in surveying a large surface by the aid of the stage movement, you must be constantly on the watch lest, running a little unevenly, it may cause particles of dust upon the cover to rub and scratch the surface of the front combination.

The method of working with Immersion lenses has been already alluded to, and is accomplished without particular difficulty. The object to be viewed should be not far from the center of a rather large cover, in order that the fluid which bathes it may not be brought in contact with that in which the lens is immersed, or they will immediately become mixed by capillary attraction; after placing the slide upon the stage, the instrument being set vertically, a clean glass rod is to be dipped into distilled water (fresh rain-water will answer every purpose) and applied to the cover so as leave a small drop just over the circle of light concentrated by the achromatic condenser; next screw down the body of the instrument until the objective comes in contact with the fluid, and, if requisite, a little farther, watching it carefully with the eye held on a level with the stage to avoid going too far, and then incline the microscope as preferred and focus as above advised. It is necessary to renew the distilled water at intervals of perhaps an hour by carrying another drop to the upper edge of the lens by means of the rod and letting it flow in to supply the place of that which has evapo-

rated; the observer will be informed of this desiccation by seeing a sort of cloud fly rapidly across the field of view, after which passage objects seen clearly before become suddenly indistinct. It has occurred to me that a lens so adjusted as to give a clear image, when immersed in glycerin, would have some advantages, such as avoidance of this drying away of the fluid, and on account of the higher refractive power of the liquid, increased amplification, and greater working distance; perhaps, however, some different cement for the lenses would be required. It has been objected that immersion lenses are less durable than others, on account of even water in time disintegrating the cement employed, but my $\frac{1}{25}$ has been in almost daily use, not unfrequently for several hours a day, and often as an immersion lens, without any sensible deterioration.

Dr. Beale very judiciously advises that the young microscopist should guard against injuring his sight by working at first with low powers, rather feeble illumination, and for only short periods at a time, always ceasing his efforts as soon as the eyes become fatigued, which may be in fifteen or twenty minutes at first, although by practice he can observe for four or five hours without cessation; he should learn as rapidly as possible to work with both eyes open and with either eye at pleasure. The microscope should be covered with a glass shade (or a cone of glazed paper), when not in use, to protect it from dust. The front combinations of all objectives may be cleaned by breathing on them gently and wiping them carefully with a soft linen rag or old silk handkerchief which is quite free from particles of dust; the compound lenses which make up the objectives of $\frac{1}{4}$ inch focal length and over may be screwed apart and polished in the same way, but the higher powers should be sent to an optician when they become dirty.

Presuming that the student who has faithfully followed the instructions above given will have become sufficiently familiar with the *modus operandi* to adapt my further directions to his own instrument, even if different, I shall describe the remaining manipulations with less tedious minuteness.

Objects magnified beneath the microscope may be drawn by placing a piece of paper, supported on cardboard, exactly on a level with the stage, and looking with one eye through the instrument and the other at the paper, when, after a little practice, the image will seem to be projected on the paper, and may be drawn with a pencil. With a camera lucida or steel disk this can be done much more satisfactorily, placing the body of the microscope in a horizontal position (previously clamping the glass slide so that it may not drop forward), slipping the camera on the eye-piece, and adjusting the paper upon the table beneath. Some persons find a difficulty in seeing the point of the pencil at the same time with the object, usually either from having the paper too shaded or else too strongly illuminated, or from trying to draw something in the middle instead of at the edge of the field. If the drawing is desired smaller than the magnified object, the distance from the camera to the table must be less than that from the top of the eye-piece to the stage ; if the same size, this must be equal, and if larger (as for class demonstration), you must place the instrument so that the eye-piece projects over the edge of the table, and the image is thrown upon paper placed on a chair or on the floor, and draw with a long pencil.

To measure the size of a magnified object as enlarged by any particular combination of eye-piece and objective, if you have either a slide, or cobweb, eye-piece micrometer, is very easy after you know to what the divisions are equivalent ; thus, for example, should you find that with

the $\frac{1}{4}$ inch objective the $\frac{1}{1000}$ of an inch equals one notch and a half of the cobweb micrometer, and a salivary corpuscle occupies the space between the threads when just three-fourths of a notch (75°) apart, simply multiplying 1000 by the number of degrees required to include $\frac{1}{1000}$ of an inch (150°), and dividing the product by the number required to include the object, will give the denominator of a fraction, whose numerator is 1, expressing the diameter in parts of an inch $= \frac{1}{2000}$; the formula in brief being, if we represent the number of degrees of the micrometer found equal to $\frac{1}{1000}$ of an inch by a, the number of degrees equal to the diameter of the object, with the same magnifying power, by b, and the denominator of the fraction expressing the actual diameter of the object by x, we have $b : a :: 1000 : x$ or $x = \frac{1000\,a}{b}$. If unprovided with an eye-piece micrometer, you must first have measured the amplifying power of the lens and objective (which being once known, you should record on a slip of paper pasted upon the inside of the door of your microscope box), and then drawing the object upon paper held on a line with the stage (or if the camera is used, at an equal distance from the eye-piece), measure its size, as so delineated, in inches and decimal parts of an inch, and divide this number by the number of diameters your instrument magnifies, which will give its actual magnitude; for example, if you find a salivary corpuscle, when drawn on the paper, measures $\frac{1}{10}$ of an inch as magnified under your $\frac{1}{4}$ inch objective and No. 1 eye-piece, having a power of 200 diameters, you find, dividing $\frac{1}{10}$ by 200, that the actual size of the corpuscle is $\frac{1}{2000}$ of an inch.

In determining the magnifying power of any combination of eye-piece and objective, some standard is necessary, and the stage micrometer, ruled to $\frac{1}{1000}$ of an inch, is generally employed; this is to be placed upon the stage, the

lines brought into focus, and a drawing made very carefully of them upon paper, held exactly on a level with the stage; the average distance of the lines thus depicted is then to be measured with dividers, upon the scale of equal parts, used in surveying, and the fraction of an inch, to which it is equivalent when multiplied by 1000, will give the magnifying power of the combination; thus, if the drawing made of the micrometer lines, as seen through the $\frac{1}{4}$ inch objective and No. 1 eye-piece, represents these one-fifth of an inch apart, multiplying this fraction by 1000, you find 200 as the magnifying power; while, if the same objective with the No. 2 eye-piece gives a picture in which the lines are three-tenths of an inch apart, multiplying this fraction by 1000, you obtain 300 as the magnifying power. It is a fact, not generally, or at least universally, known, that variations in the adjustment for the thin glass cover make important differences in the magnifying power of the lens, arrangement for the thickest cover giving the greatest amplification. If unprovided with a micrometer, you may prepare a standard accurate enough for ordinary purposes by passing a small camel's-hair brush, dipped in fresh human blood from a healthy man, across a slide, allowing it to dry, and then making a drawing of four of the red corpuscles (as magnified) of average size, which have happened to lie in a line just touching, but not overlapping each other; seven-eighths of the sum of their diameters will very nearly represent $\frac{1}{1000}$ of an inch, and hence you can calculate the power of that particular eye-piece and objective, according to the rule above given. Much time may be saved by ruling upon stiff cards lines representing thousandths of an inch, as magnified by different lenses in various combinations, since it is very easy to approximate quite closely to the diameter of a magnified object by holding the proper scale on

a level with the stage and projecting the image seen through the microscope upon it, as in drawing.

The application of reagents is to be made in the way already directed for coloring the epithelial cells with aniline (p. 45), except that should the fluid have become dry at the edges of the cover a small strip of blotting-paper, moistened at its tip, should be placed at the opposite angle or side, in order, by its capillary attraction, to draw the test liquid beneath the thin glass. After a few experiments with aniline, the student may proceed to act upon the leucocytes of pus with acetic acid, and when quite familiar with the process, may endeavor to dissolve some oil globules, as those of milk, in ether, under the microscope. While using reagents, it is advisable to erect the microscope so that the stage may be in a horizontal position, in order that corrosive fluid may not run down upon and injure the brass-work of the stand. The growing slide, which is very useful in subjecting bodies to a continuous current of water or an aqueous solution, consists merely of a common slide, upon one end of which has been cemented, by gold size or other material, a small glass vial that can be filled with water, and supply it very gradually by means of a soft cotton thread, to the upper edge of a cover placed upon it.

I have already advised the student to procure the assistance of some experienced microscopist in examining the goodness of his lenses, but as this may sometimes be difficult, shall subjoin a few remarks upon such investigation. Epithelial cells and salivary corpuscles may always be procured as described above (p. 45), and, in addition to these, the dark and light scales of the Podura (to be had, mounted, of most opticians) are excellent test objects; the dots upon the cells should be shown sharp, clear, and distinct, as those in Fig. 4, or even as in a fine steel engraving, with the No. 1 eye-piece, and, in a general way, the deeper the eye-

piece with which their outlines continue to present this character, the more perfect is the lens. The able editors of the Micrographic Dictionary recommend, among others, the following as test objects of the different powers: "For the 1 inch or $\frac{2}{3}$ inch object-glass; magnifying power 60 diameters; angular aperture 22° to 35°. Hair of the dermestes" (larva of D. lardarinus, or bacon beetle), "of the bat, the pygidium of the flea, the outline of the areolæ being distinguishable under the high eye-piece (120 to 200 diameters), but not the rays. Also an injection, as a piece of lung. $\frac{1}{4}$ inch object-glass; magnifying power 220 diameters; angular aperture 75° to 140°. Tests—hair of dermestes; the discs of deal; the salivary corpuscles, the moving molecules being clearly distinguishable; the smaller scales of Lepisma" (L. saccharina, or silver fish, found on old books, etc.), "the scales of Podura; the filaments of Didymohelix; the pygidium" (the ninth and last segment in the abdomen of the female) "of the flea; and the scales of Pontia brassicæ. $\frac{1}{8}$ inch object-glass; magnifying power 420 to 450 diameters; angular aperture 110° to 150°. Tests—the paler scales of the Podura; the pygidium of the flea; the scales of Pontia brassicæ; the filaments of Didymohelix, showing the component fibres; the salivary corpuscles." As tests of definition and angular aperture, the valves of some Diatoms, such as the Pleurosigma angulatum, and the Surirella gemma, may be resorted to for tests of the high powers, —that is, those above $\frac{1}{8}$ inch. Nobert's test plate is composed of a series of bands of fine lines ruled very closely together by some process kept secret by the operator. Lieut.-Colonel Woodward has recently succeeded in resolving the lines in the nineteenth band, which number 57, or 114,000 to the inch. (See *American Journal of Science and Arts*, Sept. 1869.) In a paper read before the Royal Microscopical Society of London, October 13th, 1869

(*Quarterly Journal of Microscopical Science*, Jan. 1870, p. 94), Dr. Woodward states that, while the immersion $\frac{1}{16}$ of Powell & Lealand resolved the nineteenth band, their $\frac{1}{25}$ and $\frac{1}{50}$ and an $\frac{1}{8}$ of Wales, all dry lenses, resolved the fifteenth band, but not the sixteenth; an immersion $\frac{1}{15}$ by Wales resolved the sixteenth band, but failed to go further; an immersion $\frac{1}{20}$ by Wales and a Hartnack immersion No. 11 resolved the seventeenth band, but failed to go further.

In adjusting an objective for the thin glass cover of an object, Dr. Beale directs to arrange the lenses so as to give the best definition of an uncovered object; then focus some object covered with the thin glass, and, without moving the body of the microscope, turn the screw collar until any particles of dust on the upper surface of the cover come into view, when the required correction is accomplished; or the adjustment may be made by repeated trials with the screw collar of the objective at different points, carefully observing with which the clearest image of the object is obtained.

For testing the definition of high powers, such as the $\frac{1}{16}$, $\frac{1}{25}$, and $\frac{1}{50}$ of an inch objectives, Dr. Royston Pigott, in the *Quarterly Journal of Microscopical Science* for January, 1870, maintains that the markings of the Podura scale (which he calls spectral) so generally employed by opticians as a guide by which the accurate "correction" of their objectives may be determined, are unreliable as a standard, the appearance of dots like notes of exclamation (!!) being "absolutely false and delusive." Instead of the scales of the Podura he recommends the use of very reduced images of objects, such as a globule of mercury, the face of a watch, etc., formed by a pair of minute lenses arranged beneath the stage (somewhat in the manner of an achromatic condenser), as tests of definition. In default of these, he advises the valves of certain Diatoms,

especially Pleurosigma formosum, and mentions one test which is readily obtainable by all, as follows: "A severe test is the appearance of minute hairs, $\frac{1}{50000}$ of an inch in diameter. A fine definition shows a hair to bear two black borders and a central line of light, with scarcely any penumbra (or shadowy outline), under the $\frac{1}{16}$ and immersion lens. Hairs of antennæ of male gnat were employed." For further information upon the subject, and also for a simple formula for calculating the magnifying powers of objectives combined with different eye-pieces, my readers are referred to the original paper.

As an economical means for increasing the power of an objective, the Amplifier (such as is used in the telescope) has lately been adapted by some of our American opticians. It consists of an achromatic plano-concave lens, mounted in a short brass tube, which slides into the lower extremity of the draw-tube (see page 20), so that the observer is enabled to arrange it at a suitable distance between the object-glass and the inner combination of the eye-piece. It will, as I am informed by my friend, Dr. J. Gibbons Hunt, when properly adjusted to any objective, *double* its power, at the same time it increases its working distance, without that decrease of light and loss of definition inevitable when a corresponding gain in amplification is obtained by the use of a deeper eye-piece.

Amplifiers may be had of Messrs. Tolles, Grunow & Zentmayer at prices varying from three to twelve dollars.

Some very beautiful and brilliant results may be obtained by using polarized light for the illumination of certain objects, as, for example, a minute crystal of naphthaline; but, as far as I am aware, this method possesses no great practical value, and, according to Dr. Beale, its advantages have been greatly overrated. Polarization of the light is generally effected by passing it through two crystals of Iceland spar (one adjusted in its brass setting

beneath the stage, and called the polarizer; the other arranged above the eye-piece, and named the analyzer); but tourmaline or the iodosulphate of quinine may be employed.

The use of the spectrum microscope, full of promise as it is for the future, has not as yet been sufficiently studied to render its detailed explanation necessary here. For this my readers are referred to the excellent chapter upon the subject by Mr. H. C. Sorby, in Dr. Beale's "How to Work with the Microscope," fourth edition, p. 218 *et seq.*

The high degree of perfection recently attained in photographing microscopic objects by Col. J. J. Woodward, M.D., Assistant Surgeon U. S. Army, to whom I am deeply indebted for a copy of his admirable "Report on the Magnesium and Electric Lights as applied to Photo-Micrography" (War Department, Surgeon-General's Office, Washington, D. C., Jan. 5, 1870), and its accompanying specimens of the art, should stimulate others to pursue his footsteps and to emulate (if possible, equal) these productions of our Army Medical Museum, which have hitherto surpassed those of microscopists throughout the world. (See a reprint of the report in the *American Journal of Science and Arts*, May, 1870, p. 294.)

CHAPTER III.

EXAMINATION OF URINE.

Division 1.—Light or Flocculent Deposits.

SECTION A.—*Casts of the Uriniferous Tubules—Bright's Disease.*

IN order to simplify as far as possible the subject of the microscopic examination of the urine, which, of course, forms a large and important part of the work done by the microscopist, I have adopted, with some modifications, the arrangement employed by Prof. Lionel Beale, in his invaluable work on Kidney Diseases and Urinary Deposits, as being best suited to the wants of most who will refer to these pages, by exhibiting at a glance what portion of the volume must be consulted in order to find information respecting the particular sample of urine they wish to examine.

Let us suppose that a specimen of urine is offered for investigation (some history of the patient being also supplied, as should always be the case); when possible, it is generally best to direct that four fluidounces of that passed on awaking in the morning after a night's sleep should be emptied from a clean vessel into a bottle that has just been thoroughly washed with fresh water, which should be stopped with a new cork, and brought to the physician's office within three hours from the time it was voided; nor is this an excess of precaution, as many who have been puzzled and misled by some accidental impurity occurring in the fluid will, I think, admit without question.

On its reception, the urine should be poured into a conical glass, of about five ounces capacity, carefully covered with a piece of cardboard to exclude dust, and set aside where it will be undisturbed, for about twelve hours; at the end of this period, any existing sediment, which is likely to be let fall at all, will have subsided, and a moment's glance will decide whether such deposit is Scanty, granular, or crystalline, in which case consult Chapter VI., Dense and bulky, when it will be found described in Chapter V., or Light and flocculent, which brings it in the present division. In order to determine whether it belongs to Section A. or B., however, the urine should be tested for albumen in the usual way, by boiling a couple of fluidrachms in a test-tube, and also by the addition of a few drops of nitric acid, when, if no precipitate, or even the slightest cloudiness, is produced, the sediment probably consists of mucus, spermatozoa, vibriones, or bacteria, as pointed out in Chapter IV., while, if an albuminous coagulum is formed by the reagents above mentioned, tube-casts, such as I am about to describe, will generally be found.*

Presuming now that a deposit has been let fall to the bottom of the conical vessel containing this albuminous urine, a glass tube pipette, of suitable length, is selected, the larger opening firmly closed by the forefinger, and the tapering extremity carried down to the very bottom of the glass, beneath, or at least in contact with the layer of sediment there formed. The pressure of the finger at the upper opening of the tube is then slightly relaxed, and a small quantity of the urine, with some of the deposit in suspen-

* I have seen a few cases in which extremely delicate Hyaline casts were visible in sediment from non-albuminous urine, but so difficult were they of detection that it seems to me only an experienced microscopist, working with a superior objective, could be blamed for not discovering them.

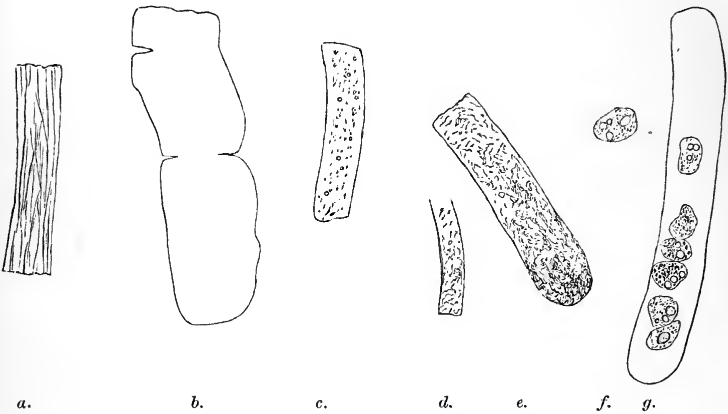
sion allowed to enter our tube until about one inch of its caliber is filled, when the superior aperture is to be tightly closed as before, the tube withdrawn, about half of its contents allowed to flow out, and the external surface wiped off with a piece of new muslin or linen.

A glass slide and cover having been previously prepared, as described in Chapter II. (p. 34), the pipette, still closed at its upper end by the forefinger, is brought in contact with the middle of the slide, and the finger raised slightly so as to permit the exit of a single drop of its contents, which is immediately covered with the square of thin glass, and any excess of urine which may exude at the margin of this cover, removed by bringing in contact with it the ragged edge of an old piece of muslin, when it will be quickly absorbed; great care must be taken not to push the cover upon the stratum of urine between it and the slide, as a very slight movement of this kind will greatly modify the microscopic appearances. I have seen at least a thousand collections of blood corpuscles so aggregated together into cylindrical masses as to accurately imitate the tube-casts of Bright's disease, all produced in a moment by neglect of this precaution.

The specimen is now ready for examination, and is therefore placed upon the stage of the microscope, a moderate light thrown upon it from beneath by the mirror; and the objective, which should be a quarter, one-fifth, or one-eighth inch (giving a power of from 200 to 400 diameters), brought to its proper focal distance above it, as described in Chapter II. under the head of Manipulations. (See page 46 *et seq.*). In order that a thorough examination of the contents of the drop may be made, it is well to conduct the investigation systematically from a certain point, as for example the upper right-hand corner of a thin glass cover, half an inch square, moving the stage in a horizontal

direction until the upper left-hand corner comes into view (or as far in that course as the adjustment of the stage will permit), then raising the stage in a vertical direction, the width of a single field, reversing its former horizontal motion until the right border is again reached, and so proceeding like a farmer plowing backward and forward across *his* field until no portion has been neglected, or until the observer is quite satisfied in regard to the nature of the deposit.

FIG. 5.



TUBE-CASTS OF BRIGHT'S DISEASE. × 220 DIAMETERS.

a. Fragment of linen fiber, resembling a tube-cast in size and shape. *b.* Large hyaline cast. *c.* Small pale granular cast. *d.* Very small granular cast. *e.* Medium-sized dark granular cast. *f.* Epithelial cell, showing oil globules of fatty degeneration. *g.* Fatty epithelial cast.

I well remember, when a mere tyro in the art of microscopy, consulting an intimate friend somewhat further advanced, but also in the stage of pupilage, in regard to a supposed cast from a uriniferous tubule occurring in the urine of a patient believed to be suffering from Bright's disease, the nature of which we could neither of us satis-

factorily determine, although now, looking back to its appearance, I am confident that it was neither more nor less than a minute filament of flax derived from the soft linen rag with which I had cleaned the slide; and, in order to prevent others from being led into like uncertainty, I have introduced into the accompanying figure at *a*, the camera lucida drawing of a similar linen fiber, at the same time contrasting it with some well-marked tube-casts. In this particular instance the error would have been an egregious one for any but a student; but cases often occur when the detection of true casts is by no means easy, and sometimes only a very extended experience will enable the microscopist to recognize them.

In diagnosticating veritable tube-casts in the urine, I believe that the discovery of epithelial cells from the uriniferous tubules imbedded or firmly attached to the cast, as shown in the figure at *g*, is the most certain indication; of course, many casts occur without any epithelial cells, but, except in the last stages of albuminuria, when the tubules seem to be quite denuded of their cellular lining, I think it is rare to examine a whole slide charged with tube-casts (as above directed) without finding at least one or two exhibiting well-defined epithelium. The mistake of deeming that a cell which simply overlies a cast is imbedded in it, may be guarded against by setting up a to-and-fro current in the liquid by gentle taps with a mounted needle upon the cover, and so separating the two objects, if no union between them exists. Another important indication is the detection of red blood disks and white blood globules (mucous, pus, or exudation corpuscles) attached to the casts (see Fig. 6), and although this criterion is liable to the same fallacy of being confounded with mere juxtaposition of the two elements, testing it as above suggested will generally prevent mistakes.

The size of a suspected cast will often give great assist-

ance in satisfying one's self in regard to its nature, for although true casts ordinarily vary from the $\frac{1}{1400}$ to $\frac{1}{500}$ of an inch across, yet in my experience the cases where a diagnosis is difficult are those in which the casts are of rather small diameter,—not exceeding the $\frac{1}{1000}$ of an inch in thickness, and appearing, under a power of 200, about the size of those drawn at *c* and *d*, in Fig. 5; because when the disease has advanced so far as to strip many of the tubules of their epithelial lining, and so allow large and medium-sized casts to be formed, a well-marked albuminous coagulum is generally obtained on testing the urine with heat and nitric acid, and the condition of the patient (without being acquainted with which no physician should give a *positive* opinion) is usually such as to throw a great deal of light upon the subject, and prevent erroneous conclusions.

The rounded or club-shaped form of an extremity, as delineated at *e* and *g*, in Fig. 5, has often aided me in determining that some little aggregation of matter was a veritable tube-cast, since I have very rarely seen it occur, except in cases where other examinations showed casts containing epithelial cells, and rendered the diagnosis certain; such an appearance, however, is by no means a constant character, and its absence, therefore, must not be taken as disproving the existence of Bright's disease.

The test by pressure upon the cover, as described in Chapter VII., is also frequently valuable in a diagnostic point of view. When the casts are very delicate and hyaline they may often be seen more distinctly if looked for with the field of view but feebly illuminated and just outside the exact focus of the lens, a position obtained by adjusting the body of the microscope so as to give the sharpest definition of some object on the slide, as a cell of vesical epithelium or the edge of an air bubble, then raising the body by perhaps the tenth part of a turn of the

fine adjustment screw and proceeding with the examination. This method is particularly applicable to the detection of so-called *waxy* hyaline casts, which, by their greater refractive power, so concentrate the light as to become much more clearly visible.

As has been intimated above, the student who fails to discover tube-casts in the first few fields, should not at once conclude that none exist in the urine, but must patiently persevere in examining field after field, and, if necessary, slide after slide, varying the amount and direction of the illumination and the adjustment of the focus until he is sure that no bodies resembling any of those delineated as casts in Fig. 5 are visible; he should also consult and compare any doubtful aggregation of matter which he may meet, with other drawings in this volume, and also with plates of microscopic appearances, given in the text-books of medicine he may possess,* not allowing himself to be discouraged by the difficulties which waylay him, nor by a temporary want of success, but remembering that the old maxim, *Perseverentia* OMNIA *vincit*, is nowhere more literally true than among the obstacles of microscopy. I have often, as in the case of X. Y. detailed on p. 78, spent hours over a single specimen of urine, slowly and carefully examining a whole slide, composed of more than a hundred fields, without being rewarded by the discovery of a single indubitable cast, and yet in the end accumulating evidence sufficient to accurately diagnosticate the disease.

If the most careful examination, while failing to reveal tube-casts, discloses red or white blood (pus) corpuscles, it

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* As Watson's Practice of Medicine, Da Costa's Medical Diagnosis, Bennett's Clinical Medicine, Roberts or Bird on the Urine, Grainger Stewart on Bright's Diseases, etc.

is probable the urine is albuminous from admixture of serum, from hemorrhage, or from the formation of pus, as described in Chapter VI., which see.

Assuming now that the investigation, whose steps I have been endeavoring to point out with a minuteness which I fear will seem tedious to some of my readers, has, unfortunately for the hypothetical patient, resulted in the detection of well-defined casts, it becomes further an important subject of inquiry with what form and stage of Bright's disease we have to deal; a question which may generally be answered by a careful and comprehensive examination of the kind, number, and magnitude of the casts, the characters and abundance of the associated epithelial cells and blood corpuscles, and of the signs and symptoms as well as the previous history of the disease.

Recognizing, then, the superiority of the classification of Dr. Grainger Stewart,* on the basis of Virchow, for purposes of scientific study, I propose to vary somewhat the mode of arrangement adopted by these high authorities, in such a manner as to bring more prominently into view the microscopic appearances of the urine as leading indications for the diagnosis of the different forms and stages of albuminuria, premising, however, that the rules which I am able to give are subject to numerous exceptions, and must only be made use of as approximative indices, and not as infallible guides to a perfectly accurate judgment; for just as with the stethoscope and the clinical thermometer, unless particular signs are carefully read by the light of general symptoms, both past and present, the physician will constantly be liable to fall into error.

It must be remembered, too, that owing to the fact that renal disease, whether inflammatory, amyloid, or cirrho-

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* Bright's Diseases of the Kidneys, p. 8.

tic, usually exists, when it does occur, in varying degrees in different kidneys or in different parts of the same organ, the casts which are found therefore *legitimately* lead us to the conclusion that various stages of the disease coexist in the same patient; if, however, two or three specimens of the urine be examined, and the number of each variety of casts noted, a very satisfactory conclusion can mostly be reached as to the *general* or *average* condition of the renal organs.

In order to aid the student in deriving from the history of the case all the assistance toward forming an accurate diagnosis which it is able to afford, I will here endeavor to group together some of the more prominent symptoms which should direct our attention especially to a particular form of albuminuria; condensing, for this purpose, some of the admirable descriptions of Dr. Grainger Stewart.

The first or Inflammatory form of Bright's disease, which may be of long or short duration, according as it is more or less chronic in its character, generally comes on after exposure to cold or wet, or after some febrile affection, and is indicated by pain in the back, scanty but frequent micturition, the urine being dark, bloody, or smoky (if acid), highly albuminous, and depositing numerous tube-casts. The face, legs, or scrotum become œdematous, which œdema may rapidly extend. There is often fever, dyspnœa, and headache or drowsiness. Should treatment, in such cases, be neglected, or prove unavailing, the dropsy may increase and produce death by mechanical interference with the action of the lungs and heart, or the poisoned blood may so affect the brain that uræmic convulsions or coma lead the way to a fatal result. When, as frequently happens, Bright's disease exists as a complication of some more serious affection, death sometimes occurs before dropsy is developed or makes much progress.

In more favorable cases, however, the symptoms gradually abate, as in the following example, which I quote from my paper "On the Diagnostic Value of the Corpuscular Blood Elements in the Urine," in the *Am. Jour. of Med. Sci.* for January, 1870:

"CASE IV.—Exemplifies that frequent occurrence in the course of Bright's disease, an acute attack supervening upon one of the chronic forms, as follows:

"Ellen G., cloakmaker, æt. 29, unmarried, was admitted into the Women's Medical Ward of the Pennsylvania Hospital, May 2d, 1869, during the service of Prof. J. Aitken Meigs, who has kindly permitted me to report the case. The patient stated that her father died of consumption twenty-six years before, and her brother of dropsy in his twenty-second year. She had worked very hard at her trade for the last ten years, sometimes as much as fifteen hours daily, and during that time—nearly eight years since—had a severe attack of yellow fever, subsequent to which she had suffered much from dyspepsia, and been troubled occasionally with eruptions upon the face. About five weeks before admission she took a very severe cold, after exposure to wet, which was followed by a sense of weakness in the loins that gradually developed into a sharp pain in the lumbar and abdominal regions; nausea and vomiting, loss of appetite, and intense thirst came on about the same time. One week later she first noticed puffiness of the eyelids; and a few days afterward the enlargement of the abdomen and œdema of the feet and legs came on. Shortly after taking cold she noticed that she was obliged to rise three or four times in the night to pass water: also that the fluid when voided was dusky, and deposited, on standing, a sediment that looked like coffee-grounds. For the week following her exposure she had a troublesome diarrhœa, but since then her bowels have been regular, although severe griping

pains in the abdomen still persisted. Throughout the week previous to admission she had been troubled with roaring noises in the head, but she did not suffer much from headache, and her intellect was quite clear. On entering the hospital her face, feet, limbs, and abdomen were all very œdematous, and her countenance presented the pale, waxy hue of Bright's disease in a very marked degree. A specimen of her urine, examined on the 24th of May, was of a dark, reddish-brown color, specific gravity 1010, and contained about one-third of its bulk of albumen as coagulated by heat and nitric acid. Under the microscope I found the abundant deposit let fall on standing was composed of large numbers of red and white blood corpuscles in the estimated proportion of twenty-five to one, much granular débris, and some well-defined casts, granular, fatty, and fibrinous, all more or less stained with the hæmatin from the decolorized red globules; some of the tube-casts had imbedded in their substance epithelial cells which had undergone marked fatty degeneration, many of the oil globules measuring $\frac{1}{10000}$ of an inch in diameter. Under the influence of appropriate saline diuretics the flow of urine rapidly increased, and five days after the above examination was made the amount passed in the preceding twenty-four hours measured 112 fluidounces, which free diuresis soon produced a very satisfactory decrease in the anasarca and ascites; but I was unfortunately prevented by illness from making further examination of this patient, and can only add that she was discharged from the hospital on the 7th of August very much relieved."

In some instances a slight amount of disease in the kidneys persists for months, giving rise to the formation of delicate hyaline casts, having white blood corpuscles imbedded in them, as in the following example also quoted from the same article:

"Case VI.—X. Y., merchant, native of Philadelphia,

but for some time past residing in one of the New England States, came under my observation August 8th, 1869. From his family medical attendant I learned that about six weeks before, he had been exposed to cold and wet, which, acting upon a constitution enfeebled by the poisonous effect of lead and various other causes not necessary to mention here, had resulted in an ill-defined febrile attack, attended with pain in the back, and high-colored urine; but that unfortunately from the fact of the physician himself being at the time an invalid, no examination of the renal secretion was then made. During the first week in August he was seen in consultation by Prof. Alonzo Clark, of New York, who, on testing the urine, discovered, as I was informed, a notable amount of albumen and several delicate hyaline casts of the uriniferous tubules. My first examination of the morning urine, made during the evening of August 9th, with the precautions above described, showed in three-quarters of a square inch of urinous film twenty-five or thirty epithelial cells, some of which inclosed very minute oil globules, about an equal number of free white corpuscles, and some exceedingly delicate hyaline casts, two of which contained one or more leucocytes; no red blood globules were detected; on testing with heat and nitric acid only a moderate opalescence of the liquid was produced, but this trace was deposited next day into a thin film upon the bottom of the tube, which proved entirely amorphous under the microscope. Frequent examinations of the urine from this patient were made with similar results, except that the amount of albumen gradually decreased until on the 27th of August my note-book states that the urine was clear and normal in both color and quantity, and on testing with nitric acid not the slightest cloud was visible, nor was any produced by long boiling of the acidulated liquid. Four fluidounces set aside in a conical glass for two hours let fall a scanty

flocculent deposit, which, under the microscope, was seen to be composed chiefly of epithelial cells and white blood corpuscles, but also contained a few very delicate hyaline casts. Three-quarters of a square inch of urinous film when carefully examined showed three transparent casts, one of which contained four white blood cells (pus corpuscles). On the 10th of September the urine was found free from all traces of albumen, and in half a square inch of urinous film I could only discover two hyaline casts, the longer containing two epithelial cells apparently healthy, and three leucocytes, the shorter no epithelium, and but one white blood corpuscle.

"Except during the first two weeks after I began to investigate his case, this patient had no symptom of renal disease, save the constant, although scanty, deposit of casts, white blood corpuscles, and epithelial cells let fall every day by the urine, and although suffering from other effects of disease which complicated his case, the kidneys, on the 20th of October, when I last heard from him, appeared to have become gradually restored, if not to health, at least to a condition in which they were capable of performing their normal functions."

The waxy or Amyloid, called by Dr. Dickinson the Depurative form of Bright's disease, much less common in this country than the inflammatory type, is characterized by the following peculiarities: The patient, who has generally been the subject of some long-continued wasting disease, such as tuberculosis, scrofula, caries, syphilis, etc., or who is naturally of a feeble constitution, feels more thirst, increased weakness, and finds he is passing more water than he was formerly accustomed to do; slight œdema of the feet and ankles is observed, and the urine, on examination, is found to be albuminous, and to contain a few hyaline casts. The blood shows an increased proportion of white blood corpuscles and a marked tendency of the red

globules to "tail," indicating implication of the lymphatic glands; the liver and spleen enlarge from amyloid deposit into their substance; general dropsy gradually comes on; the urine becomes very scanty, highly albuminous, but not of great specific gravity, and contains fatty and hyaline casts. When coma or convulsions supervene, as a rule, inflammatory affection has been added, but a fatal result is more apt to occur from an exhausting diarrhœa or from phthisis. Dr. Stewart further remarks, we diagnose the Amyloid by the increased flow of urine, albuminuria, absence of dropsy, previous history, complications and appearance of the patient, *i.e.* in some cases (syphilitic?) pasty, waxy complexion, deposit of a little dark pigmentary matter in the skin, especially about the eyelids, and an air of general debility; in others a pale and clear face, with peculiar congestion on the cheeks of distended small vessels, quite above the size of capillaries.

As an example of this form of the affection, I quote the following case from p. 75 of Dr. Stewart's work:

"A. C., æt. 30, was admitted to the Royal Infirmary (Edinburgh), under the care of Dr. Sanders, May 30, 1864. She stated that she had enjoyed good health until within four weeks of her admission, but for some months before she had observed that she passed a larger quantity of urine than natural. She was obliged to get up several times during the night to micturate. She had a little dropsy, but it disappeared on the occurrence of diarrhœa, a few weeks before admission. Her urine was pale, of sp. gr. 1010, contained much albumen, always exceeded 60 oz. daily, although she was affected at the same time with severe diarrhœa. She had frequent vomiting, gradually became exhausted, and died June 28. Her family was strumous. There was no positive evidence of syphilis, but she had a cachectic appearance, and complained much of pain in her bones.

"*Autopsy.*—The body was somewhat emaciated; the heart and lungs were natural. The bronchi contained much muco-purulent fluid. The liver was large, weighed four pounds and six ounces, was bound to the diaphragm by numerous old adhesions; it was fatty and waxy throughout; both the cells and the vessels were waxy. Both kidneys were enlarged; the left weighed 9½ ounces, the right 7½ ounces. The vessels were extremely waxy, both in the cortical substance and in the cones. The tubules were in many parts distended with a clear hyaline material, and the epithelium was in many parts finely granular. The basement membrane of the tubes also appeared in some parts waxy. The intestines were waxy."

In the cirrhotic or contracting form the earlier symptoms are very slight, and may often escape notice. It is especially a disease of male adults, more frequent in advanced life, and more common in connection with the arthritic diathesis. In some cases there is great thirst and frequent micturition, the urine being pale, of low density, often below 1010, and in amount slightly above the natural standard. Albumen, when present, is generally in very small quantity, one day distinct and the next inappreciable. Hyaline, finely granular or coarsely granular tube-casts mostly occur, but are apt to escape observation. Not unfrequently, even in an early stage, the patient suffers from dyspnœa, has a peculiar anæmic appearance, and occasionally finds a little swelling of the feet and ankles; often the eyelids are puffy and the conjunctiva dropsical, presenting the character styled by some physicians "the Bright eye." As the disease advances, the patient's strength gives way; he takes cold easily, has little power of reaction, and often suffers from coronal headache, the albumen increases in the urine, the pulmonary and gastric symptoms become more distressing, and finally

death takes place from uræmia, apoplexy, acute œdema of the lungs, or some intercurrent inflammatory affection.

Sometimes the progress of the disease is very insidious and gives rise to no characteristic symptoms, as in the following example:

Ann H., aged 28, a domestic by occupation, born in Ireland, and unmarried, was admitted into the Pennsylvania Hospital, on the 28th of February, 1870, for a slight attack of psoriasis; she was rather debilitated, and had been the subject of amenorrhœa for several months, but made no complaint of the least difficulty connected with the urinary apparatus. On the 5th of May she was weaker, suffered a little from dyspnœa, and, in spite of treatment, sank exhausted on the 6th. At the autopsy the chief lesion discovered was in the kidneys, which were much contracted, and, on microscopic examination, showed the usual evidences of advanced Cirrhosis.

Resuming now the consideration of deposits in the urine of Bright's disease, it will perhaps simplify the subject a little if we divide (for the purposes of microscopic investigation only) attacks of the affection where casts occur as follows:

Class *a*.—Cases in which the urine lets fall pale granular and hyaline casts of small diameter. Fig. 5, *c* and *d*.

Class *b*.—Cases where the urine deposits dark granular casts of small and medium diameter. Fig. 5, *e*.

Class *c*.—Cases where the urinary sediment contains casts with numerous epithelial cells, more or less fatty, imbedded in them. Fig. 5, *g*.

Class *d*.—Cases affording many examples of large casts over $\frac{1}{600}$ of an inch in diameter, whether epithelial, granular, or hyaline. Fig. 5, *b*.

According to this method of arrangement, under Class *a* are grouped cases of the Amyloid or waxy form, of the Cirrhotic or contracting form, and of that chronic Inflammatory form which often persists for months after an acute attack of Bright's disease. The differential diagnosis between these can only be made, as above remarked, by a thorough investigation into the general symptoms and previous history, although some assistance may frequently be derived from the number and character of the blood corpuscles associated with casts in the urine, as described in my paper in the *American Journal of Medical Sciences* for January, 1870, p. 54. From observations and experiments there detailed I conclude that

"Whilst red and white corpuscles, occurring, as described, in the urine in their normal proportion, point to renal hemorrhage, and the same elements, when more nearly equal in number, indicate an acute or subacute nephritis, the existence of white blood cells (pus, mucous, or exudation corpuscles) alone *generally* shows a chronic or, at least, less active inflammatory condition of the kidneys: further, that a series of comparative examinations performed with the precautions above detailed at intervals of a few days affords an important guide to the effect of treatment, and to the progress of the disease; and therefore it may be, I think, safely asserted that, due regard being paid to the general symptoms and the occurrence of albumen and tube-casts in Bright's disease, we can, by a careful study of the corpuscular blood elements, as seen in the urine, diagnosticate the form and stage of the renal affection with much more accuracy than it has heretofore been customary to do." See, also, full explanations in Chapter VI.

To distinguish, then, which of the forms above enumerated exists in a patient whose urine shows the characters of Class *a*, we must carefully investigate the history of

his case and his general condition, examining each of the organs in turn with scrupulous minuteness. If we find that in former years he has been the subject of any wasting disease, that along with increasing weakness there has been an increased flow of albuminous urine without any marked dropsy, and especially if the liver and spleen are shown by percussion and palpation to be decidedly enlarged, and diarrhœa is present, the probabilities are great that we have to do with the Amyloid form of Bright's disease. Niemeyer observes (Text-Book of Pract. Medicine, vol. ii. p. 42, Humphreys & Hackley's Translation, New York, 1869): "In distinguishing between amyloid degeneration and simple parenchymatous nephritis, Traube lays great stress upon the high specific gravity and dark color of the urine in the former disease. My own observations fully confirm the truth of Traube's views, and I may add that I have been struck, not only by the darkness of the urine in amyloid degeneration, but also by its unnatural brownish-yellow color; moreover, my colleague, Hoppe Seiler, has shown that such urine contains extraordinary quantities of indican." Should inquiry disclose that the sick man is of a gouty or rheumatic diathesis, or even hereditary tendency, that he has been a sufferer from dyspepsia, dyspnœa, obstinate cough and headache, that his eyelids, feet, and ankles are somewhat or moderately œdematous, and that he has been for a long time passing an excessive amount of urine, slightly, if at all, albuminous, the presumption is that he is the victim of Cirrhosis of the kidney. In case we discover that the malady under which our patient is laboring had its origin in an acute febrile attack accompanied with scanty high-colored urine, such as that referred to in the case quoted on page 76, the deposit must further be carefully examined for red and white blood corpuscles, whose presence would point to the inflammatory form of Bright's disease. In

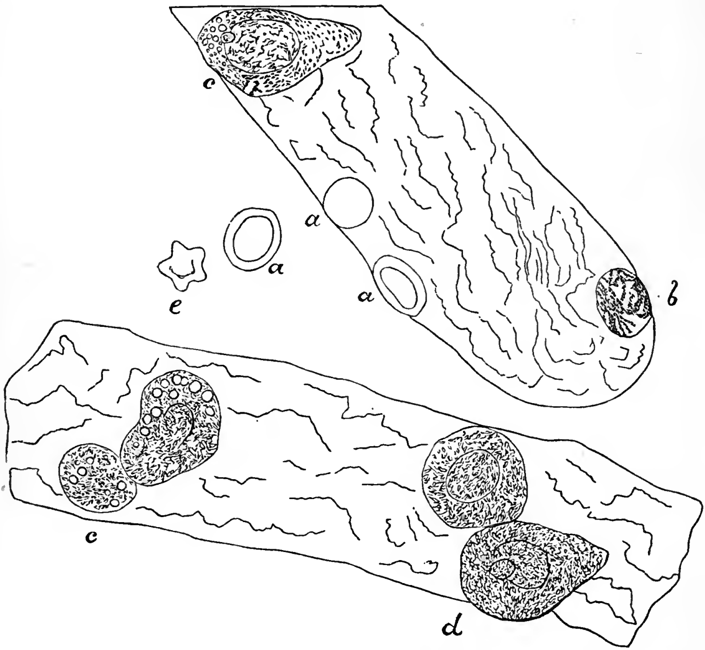
order, however, to guard the microscopist against a fallacy which may here creep in through mistaking blood corpuscles from the bladder as the result of nephritis, I quote the following from my paper above alluded to:

"Among the means of distinguishing when the effused blood is of vesical and when of renal origin, it is to be noticed that the seat of pain or soreness on pressure is one of the most important; of less general application, although of course more positive when it occurs, is the existence of tube-casts in the urine, which, when indubitable, prove, I believe, that we have to deal with nephritis; care must, however, be taken to avoid confounding accidental aggregations of matter with genuine casts from the uriniferous tubules. It is not, I believe, common to meet with more than two or three specimens of the rounded epithelium from the uriniferous tubules upon a single slide, unless desquamative nephritis exists; and should the cells exhibit distinct oil globules, even although not more than $\frac{1}{30000}$ of an inch in diameter, great force would be added to the presumption of Bright's disease, derived from the presence of the blood elements associated with renal epithelium. It is also, I think, rare for us to detect the amœboid movement, and unusual to find even the irregular shape which precedes the complete death of the motionless leucocyte in pus (white blood) corpuscles from the kidney; while this motion may often be observed in the urine of cystitis, especially if examined while fresh and without being allowed to cool below the normal temperature of the body. As mentioned by Prof. Beale, phosphatic crystals seldom occur with pus-cells from the kidney, a useful aid to diagnosis when we are able to exclude suspicion of coexisting trouble about the bladder. Of course the detection of tube-casts with red and white corpuscles imbedded in their substance is a positive index of Bright's disease."

When the urine of a patient is discovered on microscopic

examination to belong to Class *b*, and numerous red blood corpuscles, either decolorized or crenated, also occur in it, we shall probably find the patient feverish, dropsical, and urinating scantily,—in a word, presenting the symptoms of the acute stage of the Inflammatory form in greater or less intensity. When dark granular casts occur without red

FIG. 6.



CASTS OF URINIFEROUS TUBULES, SHOWING BLOOD CORPUSCLES AND EPITHELIAL CELLS CONTAINING SMALL OIL GLOBULES.

a. Red blood disks, one of them, at *e*, "Crenated." *b.* White blood globule. *c.* Fatty epithelial cells. *d.* Granular epithelial cells. × 1200 diameters ($\frac{1}{25}$th).

blood corpuscles, and in chronic stages of the disease, they generally have a blackish instead of a brownish tinge, and

consist of broken-down epithelial cells and minute oil globules, which (if very few or no casts belonging to Class *c* are present in the urine) have been probably formed in the tubules during a previous acute attack, and are gradually being washed out by the urinary flow. It must not be forgotten that pale hyaline and even mucous casts sometimes become coated with a deposit of amorphous urates, so as to appear darkly granular; this condition may be detected by gently warming the urine and so dissolving the saline material.

The indications of Class *c* point toward the existence of the second stage of the inflammatory form of Bright's disease, that of Fatty degeneration, either alone or associated with more or less amyloid degeneration. If investigation reveals a history of the origin of the complaint in an acute attack, or of well-marked acute symptoms supervening in the course of the affection (as in the case of Ellen G., narrated p. 76), if the liver and spleen show no signs of enlargement, and if the dropsy is extensive, while the strength is comparatively unimpaired, the patient is probably free from amyloid disease; while, should the reverse exist, its presence is extremely probable. In regard to the extent of fatty transformation, much may be learned by observing the number and size of the oil globules in the epithelial cells, which, if generally fatty and occupied by large particles of oil $\frac{1}{3000}$ of an inch or more in diameter, indicate that the transformation is far advanced, and that permanent improvement can scarcely be looked for.

The casts in urine belonging to Class *d* should theoretically be formed in tubes that have been quite denuded of their epithelial lining, or even have undergone distention of their caliber, and, in my experience, have almost always occurred in very advanced stages of the complaint. Nevertheless, as Dr. Beale (whose observations have been far more extended than my own) states that they are often

formed in the wide portions of the tubules, and may be seen in some forms of renal disease which are temporary and comparatively unimportant, the gravity of this symptom must not be overestimated. The form of the affection in which these large casts occur, must be decided by the accompanying deposits, history of the case, etc., as previously suggested; and if the complaint is in reality approaching a fatal issue, the symptoms will generally be so pronounced that we may readily arrive at a correct diagnosis.

Of course, instances will occur to every one where the casts deposited from the urine will partake of one or more of the characters I have endeavored to classify, and in such case the microscopist must be guided by the preponderating element, should a majority of the casts be of one kind, or if specimens of different varieties nearly equal each other in number, he may be compelled to withhold an opinion until future examinations throw further light upon the nature of the attack. On the other hand, if, in successive examinations made at intervals of a few days or weeks, the tube-casts are found, from being darkly granular and associated with blood corpuscles in the ratio of one white to fifteen or twenty red, to change to pale, granular, and hyaline, associated with red and white blood corpuscles in nearly equal proportions, or with leucocytes alone, a diagnosis of the inflammatory form of Bright's disease, commencing as an acute attack and passing into the chronic stage, might almost be predicated simply upon these facts: in a similar manner, should casts which indicate acute nephritis be gradually replaced in the urine by those belonging to Class *c* as above defined, the presumption would be very strong that the inflammatory form was passing rapidly into the stage of fatty degeneration, and a prognosis correspondingly grave, although by no means necessarily fatal, should be given. Let me

indeed warn the young microscopist against assuming that because serious disease of the kidneys is found to exist in any given patient he is therefore condemned to death from Bright's disease; for just as a man may live long with important disorganization of the heart or any other vital organ, until he is attacked with some accidental disease of a constitutional character that breaks down the already crippled powers of life and so proves mortal, so an individual with extensive but chronic nephritis may live, even enjoy life, for years, and at last fall a victim to some other affection.

And here let me state my firm belief that in the constant examination of all the organs, whenever we are called to treat any derangement of health, however trivial, we will yet find the clue to comprehending those remarkable variations of disease which have always puzzled even the masters in our profession, and by so doing be able to confound cavilers at the value of statistics (who scoffingly declare that though we know, for example, that one patient in seven will die of typhoid fever, our art fails to indicate which one of the seven is doomed to death), by pointing out, with the aid of the stethoscope and the microscope, that *because* such a one (though apparently in average health before the attack) had valvular affection of the heart and fatty degeneration of the kidneys, his strength must, in all human probability, give way under the accumulated load of disease.

Dr. George Harley (Diabetes, its Various Forms and Different Treatments, London, 1866, p. 65) observes: "When sugar permanently appears in the urine in the course of albuminuria, fears for the safety of the patient are to be entertained, because it generally indicates a loss of vital energy."

Prof. Austin Flint, in a very valuable contribution to the *New York Medical Record*, July 15, 1869, On Prognosis in Bright's Diseases (*Half-Yearly Abstract*,

Jan. 1870), affirms that desquamative nephritis may, and perhaps commonly does, end in recovery, leaving the structure of the kidneys intact. Whether recovery from the condition of smooth white kidney and fatty kidney ever occurs it is impossible to say; but it is "highly probable that, having progressed to a certain extent, the morbid process or processes, whether inflammatory or not, which these diseases involve, may cease, and retrogression take place, leaving, at length, the organs, if not intact, not damaged enough to compromise seriously their functional capacity." (See, also, An Analysis of One Hundred and Two Cases of Bright's Diseases, by the same author, *Bellevue and Charity Hospital Reports*, 1870.)

As remarked by Dr. Aitkin (p. 125, vol. ii., Science and Practice of Medicine, London, 1866), "Without a microscopic examination of the urine from day to day, it is impossible to distinguish between a case likely to improve under treatment and one which may be viewed as hopeless; and without the daily use of the microscope the treatment becomes at the best but merely guess-work."

In the management of acute Bright's disease, attended with high fever, intense dropsy, and severe pain in the lumbar regions, the indications are—first, to relieve the congested or inflamed condition of the kidneys by local depletion, such as cupping or leeching upon the loins, or, in rare cases, by venesection, following this up by revulsion from the bowels, which should be acted upon by hydragogue cathartics, energetic in proportion to the strength of the patient, such as jalap, scammony, gamboge, or elaterium, mercurials being avoided; and second, to cause the bowels, the skin, and the lungs to perform, as much as possible, vicarious nephritic duty, so as to permit congestion and irritation of the kidneys to subside under the influence of the treatment. For this latter purpose, the purgative effect first induced may be kept up by mod-

erate doses of citrate of potash or citrate of magnesia; free perspiration should be promoted by the hot water* or hot air bath and the use of acetate of ammonia with small doses of tincture of aconite or of antimonial wine, which will also assist elimination of fluid by the bronchial mucous membrane. Much difference of opinion exists as to the propriety of using diuretics in this stage. Thus, for example, Dr. George Harley observes (Albuminuria with and without Dropsy, p. 54): "In the first place, it ought never to be forgotten that in acute Bright's disease, as well as in the first stage of all inflammatory and congestive attacks occurring in the course of chronic kidney affections, diuretics are inadmissible. In the second place, it must be borne in mind that great care should always be observed in their selection; for a diuretic which will prove beneficial in one form and at one particular stage of renal disease will often not only do no good, but actual harm, when administered in another form or at another stage of the same attack. Thus, whenever the albuminuria is the result of active congestion, the antiphlogistic variety of diuretic—such, for example, as a combination of bitartrate of potash and digitalis—is to be selected; whereas, in the absence of active congestion, and more especially when the vital powers of the patient are low, the stimulating variety of diuretic may not only be used with impunity, but with actual advantage. The reason why the employment of diuretics often does harm in acute kidney affections is readily understood when we recollect that they have always the tendency rather to increase than diminish the flow of blood to the already engorged organ."

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* As a convenient substitute, Dr. Roberts recommends that a large, thick blanket should be wrung as dry as possible out of boiling water and wrapped around the body of the patient; the bedclothes are then heaped on. In twenty minutes or half an hour the hot blanket is removed and the surface quickly dried with a warm, soft towel.

Drs. Roberts and Grainger Stewart, however, assert that this prejudice against the use of diuretics has been proved quite unfounded by ample experience, which has established the value of the treatment by their aid. Among these remedies, Dr. Stewart especially recommends digitalis in the form of infusion, acetate and nitrate of potash, oil of juniper in tincture (or by inhalation from a sponge dipped in hot water), infusion of broom, and, last but not least, pure water. It seems to me, however, that diuretics, which increase the flow of urine by their influence upon the process of exosmosis instead of by their stimulating action, will probably prove most beneficial when renal congestion already exists. Mercurials should be avoided, because severe salivation sometimes follows very small doses. Dr. Roberts states that two grains of blue pill administered with extract of colocynth, on two alternate mornings, produced profuse ptyalism in one of his patients.

The management of consequent and casual complications is sometimes very important, and should receive particular attention. Obstinate vomiting may be treated with bismuth and morphia, creasote, small pieces of ice, hydrocyanic acid, or minute doses of chloroform; and dyspnœa, when cardiac, as it frequently is, may often be relieved by the aromatic tincture of valerian, or very scanty inhalations of ether or chloroform. When uræmia comes on, renewed efforts must be made to promote the flow of urine; and should convulsions occur, chloroform inhalations, and, in rare cases of vigorous subjects, venesection, may be resorted to. Frerichs, on the theory that so-called uræmic poisoning is produced by carbonate of ammonia, recommends the free use of acids, but since the experiments of Oppler, Zalesley, etc. have shown the fallacy of such views, little benefit can be expected from their administration. The secondary thoracic complications, pneumonia, pericarditis, etc., are often of unusual

severity, and yet occur when the patient is too feeble to bear the ordinary antiphlogistic treatment. Our chief resource under such circumstances must be in dry cupping and counter-irritants ("distant stimulants"), such as chloroform and mustard, avoiding cantharides and turpentine.

The diet in the early stages should be simply farinaceous, with beef-tea or chicken soup, if necessary, to support the strength; later, it may be advisable to resort to more, or even the most nutritious aliments. As stimulants, brandy in the early and gin in the more chronic stages are to be preferred, and should be given diluted and sweetened to the taste. A complete suit of flannel should be worn next to the skin, even while confined to the bed or the house, and residence in a southern climate, such as that of Florida or Havana, will often prove of much benefit.

The prognosis of chronic Bright's disease, although generally unfavorable, is by no means so necessarily or immediately fatal as is popularly supposed, instances of recovery being not at all rare. According to Dr. Roberts, the unfavorable symptoms are "obstinate dryness of the skin, the urine, which had previously been abundant, becoming steadily scantier, without proportionate increase in the specific gravity, evidence that the disease has existed for some years, repeated recurrence of uræmic phenomena, excessive serous effusion, excessive cardiac hypertrophy, a persistently feverish state. Speedy death is indicated by the breaking forth of pneumonia or pericarditis, by suppression of urine, or uncontrollable vomiting and diarrhœa." Dr. Beale remarks that "if the patient is very stout, appearing to be in rude health, florid and full-blooded, when the attack first appears, and especially when dropsy comes on early, and is considerable, with nausea, some dyspnœa, quick pulse, and irritable, weak heart, but without any evidence of the attack being acute,

the prognosis is bad, and the case is likely to terminate fatally in a short time."

The indications for treatment in the chronic form are—first, to remove the patient as far as possible from the influence of causes or habits which have brought on the disease, and to impress upon him the absolute necessity of living within the bounds of his reduced vital circumstances, that is, in accordance with his crippled powers of life; second, in the administration of iron and the mineral acids, the tincture of the sesquichloride probably surpassing all others in efficacy, when it can be borne by the system, although it may be replaced in part by the citrate of iron and quinine or strychnia, the lactate of iron, the saccharated carbonate, or the iodide of iron; and, thirdly, in the employment of remedial measures such as those already described for the control or cure of the dropsy and other attendant complications.

Dr. Dickinson recommends in the management of the waxy or Amyloid form the free use of potash and soda to supply the deficiency of alkaline constituents in the blood, which he believes to exist; and the method is certainly worthy of more extended trial. The Cirrhotic form is the least amenable to treatment, except in cases where it proceeds from lead-poisoning, when benefit may often be obtained from the administration of iodide of potassium or of dilute sulphuric acid.

On theoretical grounds, Küchenmeister advises limewater in large doses in Bright's disease and Nephritis following scarlatina, because of its property of dissolving proteine; and, as an empirical remedy, the infusion of Sambucus Canadensis in hard cider has of late been highly lauded by Dr. McNutt, of Marshall, Missouri. (See *Am. Jour. of Med. Sciences*, July, 1869.)

CHAPTER IV.

EXAMINATION OF URINE.

Division 1.—Light or Flocculent Deposits.

SECTION B.—*Mucus, Spermatozoa and Fungous Growths.*

ALTHOUGH the light or flocculent deposit let fall from the urine under consideration may possibly consist of blood or of pus, yet, since these ingredients generally form a sediment of small bulk occupying the bottom of the vessel, and occur in albuminous urine, they will be described under the head of Granular or Crystalline Deposits, to which the reader is referred. The only form of the Leucocyte* to be considered here, therefore, as a constituent of the non-albuminous renal secretion, is the mucous corpuscle, which, as more fully detailed in Chapter VI., may vary from the $\frac{1}{3000}$ to the $\frac{1}{1400}$ of an inch in diameter, according to the density of the fluid in which it floats.

Viewing, as I think we now must do, the pus, mucous, and white blood corpuscles as precisely identical, it becomes simply impossible to distinguish the fluids in which

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* While differing somewhat from M. Ch. Robin in regard to the histological structure of the white blood corpuscle, I prefer to use the convenient name of Leucocyte, introduced by that distinguished microscopist, as a term for all the various bodies denominated by different writers pus corpuscles, exudation globules, pyoid corpuscles, mucous corpuscles, salivary globules, etc., which recent investigations tend to show are one and the same anatomical element. See Chapter VIII., On the Examination of Pus, etc.

they respectively occur (pus, mucus, and blood) from each other by differences of the size, shape, number of nuclei, etc. of their Leucocytes, so that we will be obliged to seek some other modes of recognizing them than those taught by the older microscopists. I shall, however, reserve the full discussion of this subject for a future chapter, merely remarking here that in blood we of course find, with the microscope, not only the red and white corpuscles, but, on testing with heat and nitric acid, albumen of the Liquor sanguinis; in healthy mucus, which is a *secretion*, we have only the Leucocytes suspended in a fluid which, having been acted upon by the "germinal" matter of the epithelial cells, no longer contains albumen (or, at least, albumen coagulable by ordinary reagents); while in pus, which is an *exudation*, we find Leucocytes floating in the blood serum, which, having transuded through the walls of the vessels, constitutes, in a more or less pure condition, the *Liquor puris*.

The appearance of mucus can be very satisfactorily studied in healthy urine, where it generally forms a light, semi-translucent cloud occupying the lower fourth or fifth of the fluid; if a small portion of this be placed upon a slide, as directed in the last chapter (p. 69), and examined with a power of 200 diameters, a few rounded or oval cells, about $\frac{1}{2500}$ of an inch across, will be seen imbedded in the transparent mucin, which is sometimes almost invisible, and at others presents a delicately fibrillated appearance; together with these, a small number of epithelial cells from the various parts of the urinary tract may generally be detected. Should any portion of this extensive mucous membrane become irritated or diseased, we shall find in the urinary deposits not only a much greater abundance of Leucocytes, but also numerous cells of its epithelium, which in this way become guides to the actual seat of derangement. (See Fig. 7.)

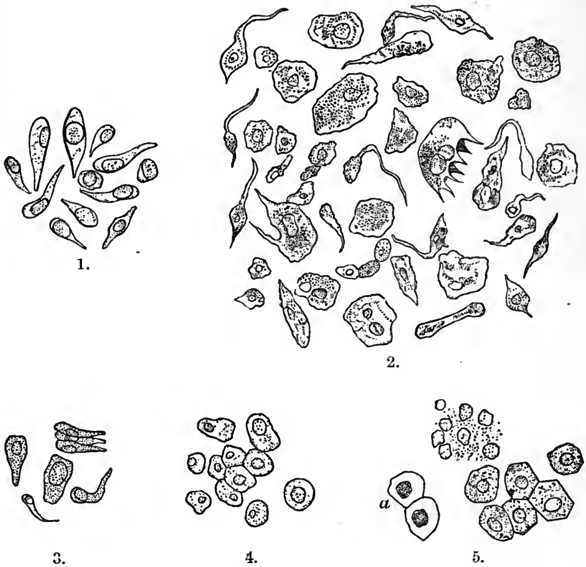
The epithelium of the bladder (Fig. 7, [2]), as stated by Dr. Beale, "varies much in different parts of the organ; in the fundus there is much columnar epithelium, mixed with large oval cells; whereas in that part termed the trigone large and slightly flattened cells, with a very distinct nucleus and nucleolus, are most abundant. Columnar epithelium appears to line the mucous follicles, while the scaly lies on the surface of the mucous membrane between them. Many of these large oval cells of bladder epithelium lie upon the summits of several columnar cells, and their under surface exhibits corresponding depressions. The epithelial cells of the urethra ([1]) are for the most part of the columnar form, but mixed with this there is also a good deal of scaly epithelium. Toward the orifice the epithelium is almost entirely of the scaly variety. The cells from the ureter ([3]) are of the columnar form, and some are spindle-shaped. In form and, indeed, in their general appearance these cells much resemble those found in some schirrous tumors. Care must be taken not to mistake them in cases of suspected cancer of the kidney. The epithelium of the kidney differs somewhat in its characters in different parts of the tube and also at different ages. That in the convoluted or secreting portion of the tube ([5]) is described as being polygonal; it projects into the tube to the extent of one-third of its caliber. The epithelium in the straight portion of the tube is flatter and approaches to the tessellated variety." The epithelium from the pelvis of the kidney ([4]) is in part tessellated and in part columnar, like that of the ureter.

As the method of investigating a fluid for epithelial cells has already been very fully described, it seems unnecessary to repeat any directions for their detection in urine, the process for a tyro being precisely analogous to that given on page 47.

Many specimens of urine are supposed to contain large

amounts of mucus, when in reality the ropy, transparent deposit is composed of pus altered in this way by carbonate of ammonia derived from the decomposition of urea

FIG. 7.



EPITHELIAL CELLS OF THE URINARY TRACT. × 215 Diameters. (After Beale.)

1. Epithelium from the urethra. 2. Ditto from the bladder. 3. Ditto from the ureter. 4. Ditto from the pelvis of the kidney. 5. Ditto from the convoluted portions of the uriniferous tubules; *a*. Treated with acetic acid.

(or by reaction with basic phosphate of soda, as suggested by Dr. Owen Rees); such cases may generally be recognized by examining the urine immediately after it is passed, or, if necessary, by washing out the bladder and drawing off a specimen an hour or two afterward. Mucus sometimes appears in the urine in the form of casts either of the uriniferous or of the seminiferous tubules; the

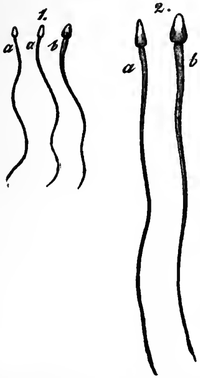
former of these two may generally be distinguished from tube-casts of Bright's disease by being often long, bent, twisted, and sometimes branched, while the latter are mostly of much greater size, and contain spermatozoa. When a deposit of amorphous urates occurs upon casts of this character, they may strongly resemble the pale granular or dark granular casts of nephritis, but may be distinguished by becoming transparent when the urine is warmed, by that fluid not being albuminous, and by the absence of symptoms of Bright's disease. Mucous casts of the uriniferous tubules generally accompany an irritable condition of the bladder of long standing, and probably often indicate a sympathetically unhealthy condition of the renal organs.

Should the Light or flocculent deposit under consideration fail to exhibit the appearances above described as characteristic of mucus, the examination should be carefully repeated upon another specimen, as before directed, for Spermatozoa. Of course, in actual practice these bodies, as well as tube-casts, etc., will all be looked for upon a single slide and in every field; but for beginners, and for the purpose of description, it will be more convenient to consider them as discovered by separate research.

In examining the urine for Spermatozoa, a small portion of the light cloud which they form (sometimes so faint as to be almost imperceptible) should be covered with thin glass upon a slide and investigated as directed on page 69, with an amplification of 200, although they may be more readily and certainly detected by using a higher power, such as 400 or 600 diameters.

As will be seen by the accompanying figure, these little bodies present the appearance of minute tadpoles with greatly elongated tails. The length of the head is about $\frac{1}{3000}$ of an inch, and that of the tail averages $\frac{1}{250}$ of an inch. The whole spermatozoon has a peculiar bluish tint,

FIG. 8.



SPERMATOZOA. (After Kölliker.)

1. Magnified 250 diameters.
2. Magnified 600 diameters.

a. Viewed from the side.
b. " " back.

and a kind of fatty luster, which renders it, like the spores of the yeast-plant and some hyaline tube-casts, most easily detected when just outside of or beyond the exact focus. As seen in the urine, they are almost always motionless, their remarkable movements promptly ceasing on contact with any acid liquid, but when detected in healthy alkaline vaginal mucus (see Chap. XII.) their very active vibrations are often plainly visible. The appearances of spermatozoa are so characteristic that, as a rule, there is little danger of their being mistaken. In an interesting case which occurred in the Pennsylvania Hospital during the summer of 1869, a specimen of urine which exhibited numerous small crystals of oxalate of lime and a great many tiny fragments of cotton fiber was pronounced by the resident physician to contain also a few spermatozoa; and under the hospital microscope, with a power of 250, certain bodies were to be seen which did indeed strongly resemble the products of the testicle, except that I thought their tails had not their characteristic regular decrement in diameter from their cephalic to their opposite extremity. On examining a specimen at home, however, under my own instrument, with a power of about 1200, I found that the head of each of these bodies was composed of a minute crystal of oxalate of lime, which, having deposited itself upon the end of a little fiber of cotton about the length of a spermatozoon's tail, contrived in that way to present a most respectable counterfeit of the genuine Homunculi, as old anatomists used

to call spermatozoa. Dr. Beale gives in his work on Kidney Diseases (opposite p. 330) a drawing of some vegetable filaments resembling spermatozoa. I have never met with such a growth, but should suppose from his plate, which is of course an accurate delineation, that it might be detected by the fact that a few of the filaments present a dilatation resembling the head of the spermatozoon at *both* ends of the delicate fiber which corresponds to the tail. This character I have never seen in spermatozoa, although I have twice met with instances where two specimens were united end to end (like Craniodidymic-cephalopagic monsters) by their cephalic extremities.

The clinical importance of the appearance of Spermatozoa in the urine has been greatly overestimated, since they are often necessarily present in the urine of perfectly healthy males, and only indicate the occurrence of a seminal emission, whether by coitus or otherwise, some of the spermatic fluid always adhering to the walls of the urethra and being washed out in the next succeeding or subsequent efforts at micturition; so that only when these bodies are constantly found in the renal secretion does their presence become a symptom worthy of attention. It is probable that the disease called spermatorrhœa, fancied attacks of which provide such a fruitful harvest to advertising quacks and charlatans, is extremely rare, if indeed it exists as an independent affection; for, as remarked by Dr. Beale, "The secretion of the testicle, like that of other glands, must from time to time escape; and when it is formed in undue quantity and discharged too frequently, it is usually but one of a train of symptoms dependent upon changes in the general health." The detection of spermatozoa in the urine may sometimes give a valuable hint as to the origin of obscure cases of dyspepsia and general debility, in excessive masturbation, as, for instance, when the morning urine of several days in

succession is found to be loaded with this deposit; and, on the other hand, a microscopist may occasionally render good service to one class of hypochondriacs, by proving to them that their water passed during the day at least is quite free from seminal fluid.

The detection of spermatozoa in the urine of females can lead, of course, to only one obvious conclusion, although the greatest caution must be exercised in *expressing* any opinion, always bearing in mind the possibility of error from accidental admixture of the masculine secretion *outside* of the body. A distinguished physician of this city was perfectly astounded on being informed that a specimen of urine (from a young girl supposed to be laboring under a totally different *affection*) which he had sent to me for examination contained numerous spermatozoa, and could only be convinced of the fact (so incredible did it seem, in view of the patient's social position) by an ocular demonstration. For methods of Medico-Legal investigation in regard to spermatozoa, consult Chapter XIV.

In the management of so-called spermatorrhœa, when, as is usually the case, the evacuations that so terrify the patient (whose imagination is generally filled with the anticipations of miserable life and horrible death pictured in the detestable, lying advertisements of quacks and their still viler and more deceitful books) do not occur more than three or four times a week in adults of average vigor, moral treatment, consisting of a full, plain, and clear exposition of the physiological facts in regard to the reproductive function, will often be found sufficient, provided the habit of masturbation is abandoned. In those comparatively rare cases where active remedial measures are required, Bromide of potassium, in doses of twenty grains at bedtime, or decoction of Dulcamara, of which a

wineglassful may be taken three times daily, will often prove of great service.

Should the Light and flocculent deposit be found to contain neither mucus nor spermatozoa, some form of vegetable growth, consisting either of Bacteria, Vibriones, or Torulæ, will generally be detected. One or more of these various fungi (or different forms of the same fungus) always grow in putrefying urine, and are sometimes found in that fluid directly after its emission; indeed, according to Dr. Beale (Kidney Diseases and Urinary Deposits, 3d edition, p. 322), "they are sometimes developed in urine before it has left the bladder." In decomposing urine, examined under a power of about 200 diameters, when the field is strongly illuminated, we may perceive a great number of very delicate lines, from $\frac{1}{1000}$ to $\frac{1}{3000}$ of an inch in length, most of which, when attentively examined, will be seen to exhibit active and constant movements; these are generally associated Vibriones and Bacteria; or, again, we may discover numerous rounded cells about the size of a red blood corpuscle, but of a bluish tint and fatty luster, sometimes single, but often united in chains of three, four, or more, such chains being generally curved and occasionally branched, and constituting the Torula cerevisiæ, or yeast-plant. (See Fig. 21.)

According to M. Davaine (quoted in the Pathologie Générale of E. Bouchut, Paris, 1868), who has spent much time in the study of these minute bodies, the organisms which appear in decomposing solutions of animal matter, such as infusion of beef, urine, etc., and which he denominates Vibrioniens, may be classified as follows:

1. Filaments straight or bent, but not twisted into a spiral.			2. Filaments twisted in a spiral form.
a. Moving spontaneously.		*b.* Immovable.	
α. Rigid.	*β.* Flexible.		
Bacterium.	Vibrio.	Bacteridum.	Spirillum.

In many specimens of urine, all four of these organisms may be discovered, and sometimes in warm weather, render the fluid opalescent and form a dense sediment, after a day or two of repose. The subject of their origin is one of great interest; and unless we accept the theory of the Heterogenists (Pouchet, Pennetier, Mantegazza, and now Charlton Bastian) accounting for them by the doctrine of spontaneous generation, it seems difficult to explain their occurrence in freshly-voided urine without admitting that their spores have previously existed in the blood and been eliminated by the kidneys. Much more extended observations, however, are required upon this abstruse subject, for whose further consideration the reader is referred to Chapter IX., On the Examination of Blood.

The appearance of Torula—under which head is included Hassal's "sugar fungus" (Transactions of the Royal Medical and Chirurgical Society for 1853)—and the Penicillium Glaucum, probably a later stage of both the "Vinegar-plant" and of the Oidium lactis, when it takes place within a day or two after the fluid is passed, sometimes indicates the existence of diabetes, and should always suggest to the physician a careful application of the test for sugar, although, as stated by Dr. Roberts, it may grow even to full fructification without our being able to detect any saccharine matter by chemical reagents. The best method for a student to become familiar with the appearance of the yeast-plant (see Fig. 21) is to examine

a minute portion of common brewers' yeast upon a glass slide, with a power of from 200 to 400, and, if he has time, to watch the growth of the plant in the manner directed by Griffiths and Henfry in the Micrographic Dictionary, p. 746. They state that a drop of fresh wort, having been covered with a thin glass whose edges were cemented down to prevent evaporation (as may readily be done with the cement described on p. 44), exhibited numerous torula cells, a few of which when carefully examined for about three hours underwent the following changes: at first the globules or cells enlarged until they attained a certain size; next, after a short interval of repose, there took place a projection of some point of the cell wall, which first appeared as a little point-like bud, afterward becoming larger and larger, until at last a new cell of the size of the parent cell was formed. (See Fig. 21.) These changes can be readily seen with a power of 200 diameters, but for the investigation of minute fungi in general a much greater amplification is required. Indeed, Dr. Beale states that "these and all other fungi in their earliest and simplest condition appear as minute sporules, less than $\frac{1}{100000}$ of an inch in diameter. Such very minute germs can only be seen with the aid of the highest magnifying powers,—the $\frac{1}{25}$ and $\frac{1}{50}$; and it need scarcely be said that no special characteristic differences which would justify any one in determining species can be discerned."

Among the rarer forms of fungi found in the urine may be mentioned the Sarcina ventriculi, which has now been detected by a sufficient number of skilled microscopists to render certain its occasional existence in the renal secretion. The characters of this plant (Fig. 22) will be found described in Chapter XI. Dr. Roberts (Urinary and Renal Diseases, Philadelphia reprint, 1866, p. 126) states that, although Welker considers it different from the Sarcina of the stomach, on account of the component

particles as well as the aggregated masses being of smaller size, it is probably the same fungus. The growth is usually associated with vesical catarrh, pain in the back, or other symptoms of irritation of the kidneys and bladder.

According to Dr. Beale, benzoic acid may occur as a light flocculent deposit in some rare cases of gout, and is supposed to result from the decomposition of hippuric acid. He also states that Kühne maintains, in jaundice it escapes unchanged (after ingestion) by the kidneys, instead of being converted into hippuric acid, as occurs in health.

CHAPTER V.

EXAMINATION OF URINE.

Dense and Opaque Deposits Occupying Considerable Bulk.

Urates, Phosphates, and Pus.

In the investigation of a dense and opaque deposit let fall from the urine, it becomes of importance to decide whether any albumen exists in the fluid, in which case the sediment probably consists of, or contains, pus. A small quantity of the liquid should therefore be tested with heat and nitric acid as directed on page 68, after which a specimen of the sediment should be placed upon a slide, covered with a thin glass, and examined with a power of 200 diameters, as advised on page 69. It will probably be found to be either, first, simply granular or amorphous, in which case it is composed of Urates or phosphate of lime; secondly, consisting of prismatic crystals, the Triple phosphates; thirdly, of Leucocytes floating in a slightly albuminous liquid, in which contingency the urine, if albuminous, contains pus; or, lastly, it may be made up of any two or all three of these ingredients.

When a specimen of amorphous deposit which dissolves readily on heating the fluid, and hence consists of Urates, is examined with a power of from 400 to 800 diameters, it is seen to be composed of excessively minute, transparent globules adhering to each other, often forming short lines of three to ten particles, and thus somewhat resembling the chains of spores of some vegetable growths. Should any doubt about their true nature be entertained, it may

be set at rest by heating the urine in a test-tube, when the deposit of urates will promptly dissolve; or, as suggested by Dr. Golding Bird, by placing a drop of the turbid urine in a watch-glass, gently warming it, as soon as it becomes clear adding a drop of almost any acid (preferably hydrochloric), and then, when it has grown quite cold, examining it under the microscope, when the amorphous urates before seen will be found replaced by lozenges of uric acid (see Chap. VI.).

These deposits, which are the most common ones let fall by urine, often occur in the renal secretion of persons in excellent health. They vary in color from white or light yellow to a pink, purplish, dark red, or even brownish tint, the reddish or "brick-dust" deposit being perhaps the most frequent and the one from which they derive their name of "Lateritious" (*later*, a brick). As shown by the researches of Heintz and Bence Jones, they consist of uric acid in combination with varying amounts of potassa, soda, ammonia, and sometimes lime and magnesia. The urate of ammonia, when pure, crystallizes in delicate needles, but is never found in the urine in this form, the slightest trace of chloride of sodium causing it to become amorphous and also greatly increasing its solubility. Urate of soda sometimes occurs in the urine of feverish patients, and in that of children, in the shape of small yellowish globules from $\frac{1}{5000}$ to $\frac{1}{1000}$ of an inch in diameter, either with or without sharp, spicular crystals projecting from their surface. Such crystals are believed by Dr. Beale to consist of uric acid, and he considers they have been deposited upon the surface of the globules after the latter are formed (see fig. 13).

A deposit of urates is often associated with other saline ingredients, especially octahedral crystals of the oxalate of lime. These are sometimes so very minute that they may escape detection, unless the urates are removed, as

Dr. Beale advises, by the addition of solution of caustic potash; and it is stated that urates may be decomposed into oxalates while standing undisturbed outside of the body. The characteristics of oxalate of lime and of uric acid, also a common impurity, will be given in the next chapter. Another adulteration of the sediments of urates, not unfrequently met with, is the triple phosphate, easily recognized by its large, clear, and beautiful crystals as shown in Fig. 9.

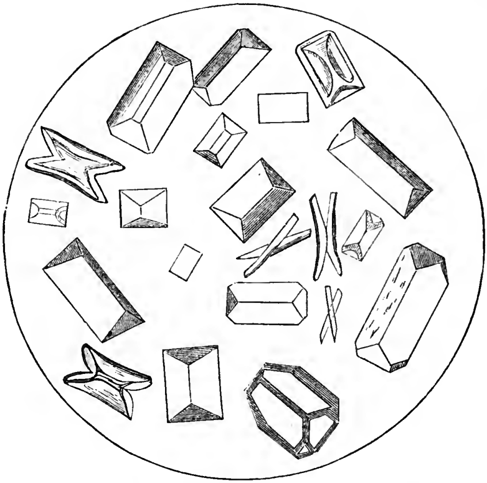
Too much importance must not be attached to the occasional appearance of a deposit of urates, as they are often observed during any slight derangement of health, or even in the total absence of disease. Most persons pass urine which lets fall a small amount of brick-dust sediment, during a common cold, or after indulging in too nitrogenous or too stimulating a diet. Such deposits are often habitual in patients suffering from disease of the thoracic viscera to such an extent as to interfere with the circulation of the blood; and it is probable that passive congestion of the liver, and slow movement of the blood through the hepatic capillaries, have much to do with this production of the salts.

The large deposit of urates which sometimes takes place when resolution of an acute inflammatory disease, such as Rheumatism, pneumonia, scarlet fever, etc., occurs, is often called "critical" and looked upon as a favorable indication of speedy recovery. Such eliminative discharge should be promoted by the administration of saline diuretics, for example acetate of potash, and diluents, such as broom, slippery elm, or flaxseed tea.

If the dense and opaque deposit let fall from non-albuminous urine does not dissolve on the application of heat, it consists of Triple phosphate (tribasic phosphate of ammonia and magnesia), or the simple phosphate of lime, either crystallized (stellar phosphate) or amorphous. On

examining a specimen of such sediment in the manner directed on page 69, crystals of the appearance delineated in Fig. 9 will probably be met with, often mingled with

FIG. 9.



CRYSTALS OF TRIPLE PHOSPHATES.* (After Roberts.) × 200 Diameters.

some granular phosphate of lime; cases of stellar phosphate being comparatively so rare that they are practically unimportant to the general practitioner, especially as this form has not been definitely associated with any particular disease.

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* The student should be apprised that this figure is made up of well-defined and typical examples of crystals selected from many different fields, or even various specimens of urine, the intention being not to delineate accurately any particular field of view, as is attempted in Fig. 27, but to exhibit as many characteristic forms as possible. A similar remark is applicable, of course, to most microscopic drawings representing *isolated* objects, as, for instance, Figs. 14, 19, 20, and 30, in this volume.

As will be seen in the figure, the crystals of triple phosphate present many varieties of size and shape. The ordinary form is that of a triangular prism with beveled ends, but many modifications are produced by the ridges and corners of the crystals being planed off as it were, so that they assume hexagonal or other polylateral figures. In urine which is highly alkaline from the development of ammonia, penniform crystals may often be observed apparently produced by a symmetrical excavation of the sides and ends of the prisms (see figure). When unmixed with any other substance, the triple phosphate crystals present to the naked eye a pure milk-white appearance, and may sometimes be recognized in this way almost without microscopic investigation. This sediment is insoluble in alkalies, freely soluble in acids, such as hydrochloric and nitric, but yet may frequently be found in urine which is feebly acid in its reaction. It seldom occurs alone, being often accompanied by urate of ammonia and uric acid, sometimes by oxalate of lime, and, in highly alkaline urine, almost always by Leucocytes and granular phosphate of lime occasionally in the form of minute dumb-bells. Should any doubt exist as to the character of a deposit of supposed phosphate of lime, it may generally be determined by dissolving the sediment in acetic acid and testing for lime with oxalate of ammonia.

The clinical importance of phosphatic deposit in the urine has long been a matter of dispute, and even yet cannot be said to have become definitely settled. According to Dr. Bence Jones, while in delirium tremens and some other forms of delirium the quantity of sulphates in the urine is often increased, that of phosphatic salts is similarly diminished; in acute inflammatory affections of the nervous system the total amount, both of sulphates and of earthy and alkaline phosphates, was found to be augmented; but, as remarked by Dr. Beale, it is very im-

portant to make sure that the superabundance of phosphatic salts eliminated by the renal secretion has not really entered the body in the food of the patient, especially as it is by no means improbable that a part of the relatively small proportion actually manufactured in the system is a product of muscular disintegration, since Dr. Hammond has shown that active exertion largely increases the amount of phosphates in the urine. In mollities ossium, where the earthy matter of bones is absorbed, an actual excess of phosphate of lime generally occurs; and it is probable that similar deposits take place during the absorption of large quantities of provisional callus in extensive fractures, and give rise to the vesical irritation not uncommon in patients so situated.

When the Triple phosphate is found deposited from acid or neutral urine, and occurs in small quantities, it often indicates only a functional disturbance of the stomach, and is accompanied by many dyspeptic symptoms, such as irregular appetite, irritability of the stomach, emaciation, extreme restlessness, and peevishness of disposition. Such urine is often rich in urea and exhibits this sediment after the patient has been subjected to some unusual mental or physical exertion. If triple phosphate, either alone or, what is more common, associated with the phosphate of lime, is let fall abundantly from alkaline, ammoniacal, or rather fetid urine, it generally indicates serious disease of the spinal cord or some organic affection of the urinary apparatus, the latter complaints being distinguished by the history and general symptoms. This kind of change in the urine seems to follow the infliction of injuries upon any portion of the spine, such as falls, blows, strains, etc., without, as observed by Brodie, being connected with the injury of any particular locality (whether in the lumbar, dorsal, or cervical regions), and is then supposed to result from the loss of vitality in the bladder, permitting the

merely chemical forces to come into play. It is, however, suggested by some authors that the vesical mucus undergoing a change so as to act as a ferment may cause the production of carbonate of ammonia from the urea; this condition is very apt to be present in cases of paraplegia, as well as in those of irritation, mechanical or otherwise, of the bladder. For distinguishing these different morbid states Dr. Golding Bird gives the following formula: "When the presence of a deposit of phosphates is independent of organic disease, it is most abundant in the urine passed in the evening (urine of digestion), and absent, or replaced by uric acid or urates, in the morning (urine of the blood), the urine being always of a tolerably natural color, never below and often above the mean density. When the presence of phosphatic salts depends on the irritation of a calculus or of organic mischief in the urinary passages, the urine is pale and wheylike, of a density below the average, often considerably so, and the earthy deposit is nearly equally abundant in the night and morning urine." According to the same lamented author, cases sometimes occur in which a deposit of large quantities of phosphate of lime occurs daily for many years without serious result, a circumstance which he attributes to its secretion in vesical mucus, instead of its being a pathological formation of the kidneys.

In the management of cases of dyspepsia accompanied with heavy deposits of phosphatic salts in the urine much benefit is often to be derived from small doses of the mineral acids, especially Nitromuriatic, given, if the stomach will bear it, in some bitter infusion, as of gentian, or in combination with nux vomica; gastric irritability being first allayed by Nitrate of bismuth or hydrocyanic acid, and constipation of the bowels overcome by aperient doses of rhubarb or castor oil. If the digestion be feeble, pepsin wine often affords important aid; and should great

irritability of the nervous system complicate the case, a pill of valerianate of zinc and extract of hyoscyamus, or the cautious use of bromide of ammonium, will frequently prove beneficial. The hypodermic use of morphia has also been found exceedingly advantageous. When the phosphatic deposit as well as the nervous symptoms can be traced to some shock of the spinal cord, this latter method of employing opiates is exceedingly valuable, and must be combined with counter-irritation along the back, as of iodine, blisters, tartar emetic, etc., and constitutional treatment with a view of building up by every possible means the general health. In cases of simple irritation of the bladder without the development of actual cystitis (as well as in the chronic stage of the latter affection) the vegetable tonics associated with iron, particularly in the form of tinctura ferri chloridi, in conjunction with the daily washing out of the bladder by injections of warm water through the double canula, should be employed. Dr. Beale remarks that "alkalies, as Dr. Owen Rees was the first to show, undoubtedly do good in some of these cases of phosphatic urine, probably by their action in promoting the normal chemical changes in the blood rather than by direct action upon the kidney or any part of the genito-urinary mucous membrane."

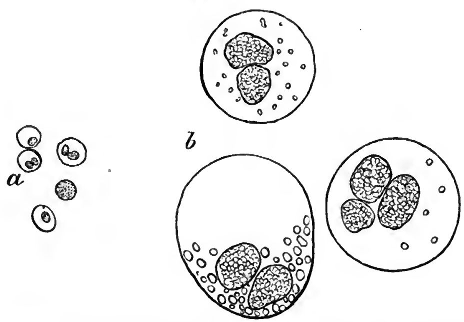
Carbonate of lime occurs rarely as a deposit from human urine, and is generally in small quantity (see Chapter VI.).

If now the specimen of dense and opaque deposit we are examining is let fall from an albuminous urine and yet contains neither red blood corpuscles nor tube-casts, but is composed of spherical cellular elements varying in different specimens from $\frac{1}{3000}$ to $\frac{1}{1400}$ of an inch in diameter, we may conclude that it is pus, and, as a further proof, will probably find that if a fluidrachm of the sediment is mixed with an equal bulk of liquor potassa in a test-tube it will

become transparent and so gelatinous and tenacious that the vessel may often be inverted without the evacuation of its contents.

As stated when speaking of mucus in the urine, the corpuscles of pus (Leucocytes) vary in size with the specific gravity of the fluid in which they float; except when largely expanded, they resemble the white blood cells, but when quite distended and about $\frac{1}{1400}$ of an inch in diameter their aspect becomes similar to that shown in the accompanying figure, drawn from specimens of Leucocytes (lying in urine of the specific gravity of 1010), in most of which the active revolving movements of the contained molecules were very distinct.

FIG. 10.



PUS CORPUSCLES (LEUCOCYTES), which, in urine of sp. gr. 1010, have assumed the SALIVARY CORPUSCULAR FORM.

a. Magnified 220 Diameters. *b.* Magnified 1200 Diameters.

The detection of Leucocytes in urine is seldom attended with much difficulty, but should any doubt arise they may be readily recognized by the following reactions. If a drop of very dilute acetic acid is placed upon the slide at the margin of the cover and allowed to flow beneath it, some of the corpuscles (if Leucocytes) will soon show one,

two, or three bright points in their interior, while if the operation is observed with a high objective or a lower one of superior excellence, the delicate cell wall of extreme tenuity may be seen surrounding these nuclei, until after a time it bursts and disappears. With an ordinary $\frac{1}{4}$ inch lens, however, it is often extremely difficult to demonstrate this membranous envelope, and the student must frequently be satisfied with seeing that in many cases two or three granules have taken the place of a single Leucocyte. By adding solution of aniline, as directed in Chapter II., in sufficient quantity to dilute the urine and so distend the corpuscles gradually, at the same time that their nuclei and cell walls are tinted, we may often obtain, even with objectives of low power, a fine view of the enlarged Leucocytes, as shown in Fig. 10, *a*. Another remarkable characteristic sometimes observed in the Leucocyte of the urine is the amœboid movement (see Chapter IX.) which, as remarked above, is chiefly to be seen when the corpuscles are effused on the vesical mucous membrane, and serves to indicate (although it does not prove) that their origin is not renal. These movements are much more active, as has been shown by Schultze in his Archives, when the specimen is warmed upon the slide to a little above the normal temperature of the body, and are especially noticeable in hot weather, doubtless because the urine does not become chilled so as to check their activity.

According to Dr. Beale, "pus" corpuscles are very common in the urine of males somewhat advanced in life while in good health; and even when the flow is abundant, amounting to several ounces every twenty-four hours, the debilitating effects seem much less marked than from a similarly profuse suppuration occurring elsewhere. The amount and character of the pain, taken in connection with the greater or less irritability of the individual temperament, are often invaluable guides to the extent of

structural change which is going on. As before mentioned (page 85), when pus corpuscles are derived from the bladder they are generally mingled with crystals of triple phosphate and with granules and spherules of phosphate of lime, which alone sometimes form a deposit to the naked eye strongly resembling pus, as in the following example: John O'Brien, a soldier, aged 25, a patient under the care of Dr. T. G. Morton, in the Upper Surgical Ward of the Pennsylvania Hospital, where he was admitted December 29, 1869, was affected with a very dense stricture of the urethra, traumatic in its origin, to relieve which, as it had already been operated upon unsuccessfully by dilatation, it was proposed to perform perineal section. Since, however, the man's urine let fall a light-yellowish sediment whose aspect exactly resembled pus, Dr. Morton suspected that a burrowing abscess of the perineum, the result of the old injury, might exist, which of course would interfere with the success of the operation; and he therefore directed a specimen of the morning urine to be sent to me for investigation. Examining $\frac{1}{4}$ of a square inch of urinous film, as recommended on p. 70, I discovered that the deposit was chiefly composed of small crystals of triple phosphate with a few epithelial cells and not more than ten or twelve Leucocytes. On receiving this report the attending surgeon determined to perform the operation, which was entirely successful, no suppurating unhealthy tissue existing to interfere with the healing of the wound.

In cities, and especially sea-port towns, one of the most common causes of pus in the urine of males is gonorrhœa, and this source may generally be detected by careful examination of the patient, compressing the urethra from behind forward in such a way as to cause any contained fluid to exude from the meatus urinarius. In women an ordinary cause of purulent deposit in the urine is leucor-

rhœa, the Leucocytes of which may often be suspected from their association with the tessellated epithelium of the vagina and their presumed origin rendered certain by further investigation of the case (*vide* Chapter XII.).

Suppuration of the pelvis of the kidney, or Pyelitis, is generally pointed out by the direct signs of irritation in the lumbar regions; and in those comparatively rare cases where such indications are absent, the diagnosis must be made, if at all, by excluding urethritis and cystitis, as directed above and on page 85, and nephritis by the history of the case and the absence of tube-casts. According to Dr. Roberts, the appearance of epithelium from the pelvis and infundibulum affords the most certain indication of this disease; these cells are very irregular, being "spindle-shaped, tailed, three-cornered, elongated, rudely circular, etc.," and the urine is generally acid.

The bursting of an abscess from pelvic cellulitis into the urinary passages is often characterized by the sudden appearance of a large quantity of pus in the urine after some weeks of suffering from fever, local pain, etc., but where the collection of pus has been very deep-seated and slowly evacuated may sometimes give rise to much difficulty of diagnosis. Dr. Bird states that an empyema has been known to find its way to the kidney, emptying itself through an ulcerated opening, and be discharged with the urine.

If the Leucocytes of pus are found in the urine, and on examination we discover a fullness or a smooth, immovable tumor in the lumbar region, especially if on percussion we are able to mark out enlarged kidney, the disease is probably dilatation of one of these organs. According to Dr. Fenwick (Guide to Medical Diagnosis, London, 1869, p. 73), there is generally tenderness on pressure, and the patient complains of pain in the loins, thigh, and testis, usually with debility and occasional night-sweats, and the disease is

generally caused by stricture of the urethra, stone in the kidney, tubercular disease of the kidney, and in the female by cancer of the uterus. If pus of renal origin is found in the urine without indications of dilated kidney, but in a patient with pulmonary tuberculosis, the disease is probably tubercle of the kidneys. Sometimes, in addition to the Leucocytes, broken-down cheesy masses may be seen, to gether with a large amount of granular débris (see Chapter VI.).

Independent of tubercular deposit, the formation of pus may take place in the kidney from ordinary phlegmonoid inflammation ending in circumscribed abscess, from pyæmia, or from renal embolism. The first is generally accompanied by pain, fever, hæmaturia, and successive, often regular, rigors; when pus is fully formed, the abscess generally bursts into the pelvis and is discharged by the ureter, but occasionally it is evacuated into the colon or duodenum, the cavity of the peritoneum, the thorax, or through the posterior wall of the abdomen. The treatment can consist of but little more than the hypodermic use of morphia, and injections to prevent constipation. When indications of pointing in the lumbar regions appear, poultices should be applied and the matter evacuated early, to prevent burrowing; but when the suppuration is caused by impacted calculi, other abscesses are apt to succeed and wear out the patient. The occurrence of secondary abscesses of pyæmia in the kidneys is less frequent than in the lungs or liver, but may be suspected in that disease if pain and soreness of the lumbar regions come on with albuminous urine in the course of the affection. The impaction of small fibrinous masses from the aortic and mitral valves in endocarditis is not very uncommon, but, unless the emboli are large, can rarely be diagnosticated during life. The first effect of obstructing an artery of considerable size in the kidney is to produce intense

hyperæmia of the surrounding parts and sanguineous effusion, so that if during or soon after an attack of endocarditis a patient experiences sudden and severe pain in the kidney, and the next day red and white corpuscles in normal proportions are found in the urine, a strong suspicion of embolism may be entertained.

The management of patients affected with chronic or subacute cystitis, sometimes called catarrh of the bladder, is, according to Dr. Beale, often unsuccessful because not properly persevered in and understood, it frequently happening that a case which has been getting worse on alternate weeks of Buchu, Uva ursi, Pareira brava, acids, and alkalies, will rapidly improve under a suitable persistence of dilute mineral acids with pepsin, stimulants, simple but nutritious food, aided by country or sea air and exercise. In all cases where the pus is converted into ropy, mucus-like masses within the bladder, that viscus should be washed out by injecting warm water every day or two, taking care not to produce dangerous distention by throwing in too much fluid.

CHAPTER VI.

EXAMINATION OF URINE.

Scanty Granular, or Crystalline Deposits.

Blood Corpuscles, Cancer Cells, Oxalate of Lime, Uric Acid, Carbonate of Lime, Cystine, etc.

If the specimen of urine we are invited to examine has let fall, upon standing as directed in Chapter III., a sediment of small bulk appearing either granular or crystalline to the naked eye, it should in the first place be tested for albumen with heat and nitric acid (see p. 68); and if found to afford a coagulum with these reagents, its deposit must be carefully investigated for *red blood corpuscles*, which will probably be detected.

The ease with which red and white blood corpuscles may be recognized in the renal secretion depends very much upon the specific gravity of that fluid; the rapid almost instantaneous occurrence of ex- or endosmosis through the cell walls of the corpuscles greatly modifying their external appearance. Thus, for example, in urine of high specific gravity the red disks will often be found darker in color than natural, and "crenated" (see Fig. 6, *e*) or stellate, from the wrinkling of their cell walls as the fluid portion of their contents passes out into the denser liquid (the same effect being produced by long soaking, in ordinary urine), while the white blood globules are opaque, spherical, and not more than $\frac{1}{3000}$ of an inch in diameter. In urine of a density approaching 1025 the red disks (Fig. 17) and white globules, if specimens are examined soon

after being voided, may often be found presenting a perfectly normal appearance; but should the urinary secretion be of low specific gravity, 1010 or less, the red corpuscles will have become spherical, colorless from the exosmosis of their hæmato-crystalline,—indeed, almost invisible to the unpracticed eye, if not aided by a very superior lens or one of high power, unless the transparent cell walls are colored by a little iodine or aniline solution (see my paper on Blood Stains, *Am. Jour. of Med. Sci.*, July, 1869). The white blood corpuscles or Leucocytes will be found nearly double their ordinary size, varying from $\frac{1}{2000}$ to $\frac{1}{1400}$ of an inch in diameter, and showing a distinct cell wall and one, two, or three nuclei (see Fig. 10), around which revolve, with great rapidity, numerous molecules,—in fact, presenting all the characters of the *Salivary corpuscular* form of the Leucocyte, which, like the alteration in shape of the red disk, has apparently been produced simply by the distention of their cell walls. These changes of shape and size, as the density of the circumambient fluid is altered, will generally enable us to distinguish blood corpuscles from the spores of some fungi which resemble them under low powers; if they do not, the urine may be set aside for a day or two, when the spores of such will manifest themselves by germination. Dr. George Harley describes a uni- and bi-maculated appearance observed in the red blood corpuscles, which he attributes to the action of the saline constituents of the urine in which they floated.

Supposing now that the deposit has been found to consist of or contain red blood corpuscles with Leucocytes, it becomes a matter of importance to decide from what portion of the genito-urinary tract these take their origin. Since the hemorrhagic elements, no matter where they are effused, present the same characters, it is obvious that cases must occur where this is simply impossible; but in a large majority of instances careful attention to all the cir-

cumstances will enable the observer to reach a correct conclusion.

A very important element in forming a diagnosis is the seat of any complaint of pain or soreness by the patient, especially if the history of the case refers to a fall, blow, or strain of that particular part. The appearance of the blood in the urine likewise guides us in some instances, being generally diffused through the fluid when of renal, and (except when small in amount) collected in coagula when of vesical or urethral origin. In the female it may be necessary to draw off the urine with a catheter for the purpose of avoiding contamination by uterine, vaginal, or hemorrhoidal discharges. (See also diagnostic points enumerated on page 85.)

Should we succeed by the considerations suggested above in localizing the point of escape of the red corpuscles, we must next endeavor to make sure that they result from true hemorrhage. If they come from an effusion sufficient in amount to form a coagulum, as is often the fact when small vessels of the mucous membrane lining the urethra, bladder, or ureters are ruptured, the case presents little difficulty; but if no clots be formed, we have but little except the location and amount of pain, as referred to on page 85, to guide us to a correct conclusion. Should this circumstance direct us to the kidneys as the seat of morbid action, the following observations quoted from my paper in Dr. Hays' *Journal* for January, 1870, may be useful:

"*First.* When the red blood globules very largely exceed the white in number, approximating to the proportion in normal blood, it is probable, as intimated above, that rupture of some small vessels has taken place, and the flow of blood is a true hemorrhage from the kidney, which may be produced by blows across the loins or lacerations caused by angular calculi. This opinion will be further

strengthened if a thorough search fails to reveal any tube-casts, and if the albumen as coagulated by heat and nitric acid is no more than should exist in an amount of liquor sanguinis corresponding to the bulk of deposit formed of cell walls from the red disks. As an approximative guide for determining this last point, I find by experiment that a fluidrachm of blood stirred up in two fluidounces of water lets fall, on standing twelve hours, a whitish deposit of fibrin and cell walls, measuring about two fluidrachms, and that a portion of the supernatant liquid tested with heat and nitric acid yields a coagulum, chiefly albuminous, occupying about one-fourth of its bulk.

"*Second.* When in Bright's disease the white blood corpuscles are mingled with red disks in a proportion exceeding one twenty-fifth of the latter, my observations lead me to conclude that generally the patient is suffering from an acute or subacute inflammation of one or both kidneys, and attended with danger therefrom more or less serious, according as the amount of corpuscular elements shows by its absolute quantity that a larger or smaller portion of the kidney is inflamed. If the albuminous coagulum produced by heat and nitric acid occupies more than one-half the fluid tested, and many times exceeds that which would be furnished by the liquor sanguinis corresponding to the blood corpuscles, an extensive inflammatory disease probably exists, unless careful microscopic scrutiny shows decided fatty degeneration (and consequent loss of secretive power) in the epithelium of the uriniferous tubules.

"*Lastly*, should we discover on examination that the white blood cells (hitherto designated as 'mucous corpuscles,' 'exudation corpuscles,' and by Dr. Beale 'cells closely resembling pus corpuscles,'—*Microscope in Practical Medicine*, p. 219) pass off from the kidneys with little or no admixture of the red disks, we may conclude that a chronic inflammation of the organs exists less

or more extensive as the number of the leucocytes is smaller or greater and as the amount of fatty degeneration, estimated as above suggested, is serious or otherwise; for my researches tend to show that the one cause of albumen in the urine varies inversely as the other; that is, if in a given case of Bright's disease the urine containing say one-fourth of its bulk of coagulated albumen after boiling shows many white blood corpuscles with epithelial cells only slightly fatty, and another specimen of the same, collected perhaps two months afterward, exhibits with the same amount of albumen few leucocytes but epithelium containing large oil globules, we may conclude that (following Dr. Grainger Stewart in his classification on the basis of Virchow's) we have to deal with the First or Inflammatory form (involving a large portion of the organs), which had passed from stage *a*, that of Inflammation, to stage *b*, that of Fatty Transformation; many cases, however, seem to run a much more favorable course, the pus corpuscles diminishing in number without any corresponding advance toward fatty degeneration in the epithelial lining of the tubules, so that the albumen slowly decreases in quantity, and the patient regains at least a comfortable state of health," as in the example of X. Y., quoted on page 77.

The diseases to which an occurrence, from hemorrhage, of red blood corpuscles in the urine point are—ulceration or laceration of the urethra, which will generally be characterized by the local symptoms and the history of the case; mechanical injuries of the bladder, either external from blows across the pubis, fracture of the pelvis, etc., or internal from the passage of instruments or from the angles of a calculus; effusion of blood may likewise take place from malignant disease of the bladder, in which case the so-called cancer cells will probably be found at some period of its course. Hemorrhage from the ureters is

almost always produced by the passage of a small stone, and the agonizing pain suffered is usually characteristic of its seat. Hemorrhage from the kidney (without Bright's disease) is generally caused by falls or blows upon the loins or by calculi imbedded in the renal substance and occupying the pelvis; the latter affection is particularly to be suspected if a flow of blood and severe pain in the back are brought on by rough riding or the lifting of heavy weights. The loss of blood from these various causes will seldom require special treatment, but in exceptional cases it may be necessary to combine the administration of gallic acid, ergot, oil of turpentine, or tincture of iron with remedies suited to the several affections.

Hemorrhage from the kidney sometimes occurs in enteric fever, in rheumatism, and in pneumonia, and, although generally ceasing in a few days, may continue until it produces an anæmic condition of the system. Intermittent hæmaturia is sometimes an epidemic disease in some of our Southern States, and occasionally proves very unmanageable, although usually yielding to full doses of quinine. (See a paper by S. F. Starkey, M.D., in the *New Orleans Med. and Surg. Journal* for October, 1869.)

Hæmatinuria (false hæmaturia) is a name applied to the condition described by Vogel and other authorities, in which the hæmatin of the blood escapes in the urine without red blood disks being present, and is attributed to the dissolved state of the blood in pyæmia, putrid fevers, and some cases of scurvy and purpura.

Should the specimen of urinary deposit be found to contain great quantities of rounded, caudate, and spindle-shaped cells, with large nuclei (see Chap. XV.) somewhat resembling the epithelium from the ureter depicted in Fig. 6, a MALIGNANT GROWTH situated in some part of the urinary apparatus may be suspected, although, on account

of the great similarity borne by the histological elements of the heterologous formation to epithelial cells above alluded to, no positive diagnosis can be made from isolated specimens; when, however, as occasionally happens, small portions of the cancerous mass slough off and are visible in the urine, the detection of such cells, imbedded in stroma, will often enable us to arrive at a definite conclusion, especially when a history of the case confirms such a view of its character. The general appearance of cancerous deposit in the urine is said to be that of a thick, dirty, blood-stained sediment, containing abundance of blood corpuscles mixed with spindled-shaped, oval, and irregular cells, pus corpuscles being wholly or nearly absent. Dr. Roberts further remarks: "In cancer of the kidney no help to the diagnosis must be expected from the character of the urinary deposit." Dr. Beale states that he has seen several cases where cancer of the bladder was detected for the first time by the microscopical examination of the urine, which let fall a deposit of a dark-brown color (resembling blood as it occurs in acid urine) found to consist chiefly of cancer cells; he also describes the appearances presented by a specimen of gelatinous-looking matter which had been passed by a patient of Sir William Fergusson's suffering with some disease of the bladder, the exact nature of whose case had been the subject of dispute, as follows: "Upon treating a fragment of it with a little glycerin and water and subjecting it to examination with a power of two hundred diameters, I had no difficulty in making out loops of capillary vessels, covered with a thick layer of cancer cells. The specimen presented the usual appearances which distinguish a cancerous tumor rapidly growing into a hollow viscus, and was evidently one of the tongue-like or ribbon processes broken off from the mass. There could therefore be no further doubt as to the exact nature of the case. The diagnosis was con-

firmed by subsequent examination of the parts after the patient's death."

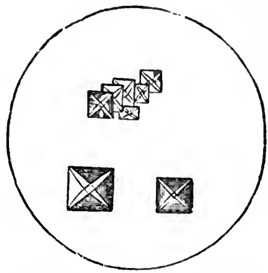
Dr. Basham (On Dropsy, 3d Edition, London, 1866, p. 424) thinks that "frequently-recurring Hæmaturia, without any sedimentary deposit in the urine in the interval, may be recognized as pathognomonic of malignant disease of the kidney."

In some cases of tubercle of the kidney it is stated by various authors that portions of tuberculous matter may be found as a deposit in the urine; and although the recent researches of Niemeyer and others (see Chap. X.) render it more than doubtful whether the doctrine of Lebert in regard to the existence of a specific tubercle cell is correct, it may not be amiss to quote the following description of tubercular elements (referred to on page 394 of Beale's work on Kidney Diseases) from p. 204 of his Microscope in Practical Medicine: "When examined under the microscope, Tubercle is seen to consist of a great number of small particles, for the most part of an oval form. They vary sometimes in size and form, are evidently solid, and have a granular appearance. The great majority of them contain nothing like a nucleus. They have been described as free nuclei, but I have never been able to satisfy myself that this view of their nature is correct. They become indistinct when immersed in glycerin, and are rendered transparent by acetic acid. Much granular matter and many minute oil globules are usually present. Tubercle corpuscles are about the $\frac{1}{2000}$ of an inch in their long diameter."

If the urine under examination exhibits neither blood corpuscles nor cancer cells, but is found to contain minute crystals apparently square and marked with a cross formed of spindle-shaped diagonals, but in reality of a flattened octahedral form, as shown in Fig. 11, the deposit is OXALATE OF LIME, and the case is one of OXALURIA. When

these crystals are of large size ($\frac{1}{1000}$ of an inch in diameter) they may be recognized with the greatest ease, and form some of the most beautiful microscopic objects to be met with in the whole range of urinary deposits, almost tempting the microscopist, for the instant, to seek out one of unusual size and have it set in a ring as a jewel; but should they happen to be very minute, as is often the case, they may readily be passed over with a low power as granules of amorphous urates or spores of fungi; if closely scrutinized, however, the particles will be seen to present a rectangular instead of a rounded form, and the question may generally be decided by examination with a power of 600 diameters, or by permitting the urine to stand undisturbed another twenty-four or thirty-six hours, to allow of further crystallization. In my experience, however, it is unusual for oxalate of lime to exist in any considerable amount without some few crystals being large enough for recognition with a good $\frac{1}{4}$ inch objective.

FIG. 11.



OXALATE OF LIME CRYSTALS. (After Bird.) × 200 Diameters.

Occasionally oxalate of lime occurs in the form of Dumb-bells, or rather, as remarked by Dr. Bird (to whose researches we owe much of our knowledge in relation to this deposit), like two kidneys with their concavities opposed and sometimes so closely approximating as to appear circular, the surfaces being finely striated; still more rarely the dumb-bells present the appearance of oval laminæ, with or without a species of nucleus, and the ordinary octahedra take the shape of square prisms crowned with four-sided pyramids, but these varieties of form generally alternate with or are soon permanently replaced by the ordinary

octahedral crystals. The lamented Dr. Bird considered it probable that the dumb-bell crystals were composed of oxalurate of lime, which differed from the common oxalate in becoming strongly illuminated by polarized light; but, as shown by Dr. Thudichum and confirmed by Dr. Beale, the ordinary octahedra do polarize, and cannot, therefore, on that ground be considered of different constitution.

In the course of investigations to determine the cause of the formation of dumb-bells, Dr. Beale arrived at the conclusion, that they result from certain conditions unconnected with any particular morbid state, appearing in the urine of persons who take little exercise and indulge in rich diet with too little water; they have been seen impacted in the uriniferous tubules, and they as well as octahedral crystals sometimes occur imbedded in, or deposited upon, tube-casts. The octahedra, especially, have a strong tendency to deposit themselves upon fragments of hair, linen fibers, etc., a curious instance of which disposition, simulating spermatozoa, is described on p. 100.

As a sediment in the urine, oxalate of lime is often associated with uric acid and urates, triple phosphate, epithelial cells, and vesical mucus. Minute crystals may be distinguished from granules of the uric acid salts by their insolubility on warming the slide, and larger ones from abbreviated prisms of triple phosphate by their insolubility in acetic acid.

The clinical importance of Oxalate of lime in the urine has been much debated, and still remains unsettled, although the most recent authorities are disposed to attribute little significance to the so-called oxalic acid diathesis. According to Dr. Bird, *Oxaluria* may occur either with or without excess of urea and extractive matter in the urine. In the former condition patients are generally remarkably depressed in spirits and of a melancholy aspect; they are often much emaciated, excepting in slight cases, extremely

nervous, and painfully susceptible to external impressions, often hypochondriacal to an extreme degree, and in very many instances labor under the impression that they are about to fall victims to consumption. There is generally inability for exertion, fever, the feet and hands being hot and dry, irritability of temper, want of sexual power, and a severe and constant pain or sense of weight across the loins, with some amount of irritability of the bladder. The urine is invariably acid and of high specific gravity, owing to the excess of urea and extractive matter. The oxalate of lime is attributed to an exaggerated activity of the second stage of the secondary or destructive assimilation, the metamorphosis of tissue of Liebig. Oxaluria without excess of urea or extractive matter is in general merely one of a series of symptoms developed under the influence of maladies which interfere with the assimilative functions; it occurs in many acute affections, such as rheumatism, and in chronic diseases attended with gastralgia, especially chronic dyspepsia, when the crystals sometimes seem to act as a local irritant to the neck of the bladder. This condition is also apt to exist associated with long-standing pulmonary disease, such as chronic bronchitis and emphysema.

On the other hand, Dr. Roberts maintains that "Intense oxaluria may continue persistently without evoking the group of symptoms attributed to the oxalic diathesis," and in this statement he is supported by the more recently published observations of Dr. Beale, who also declares, "This group of symptoms may exist in typical development without the occurrence of deposits of oxalate of lime in the urine;" and further, "The most varied morbid states coexist with oxaluria." According to F. W. Bencke, oxaluria is chiefly produced by any cause which retards the metamorphosis of the nitrogenous constituents of the blood, such as abuse of azotized articles of food, or of

saccharine and starchy substances, insufficiency of the red blood corpuscles, insufficient enjoyment of pure, fresh air, organic lesions which impede respiration and circulation, and depressed conditions of the nervous system, whether mental or otherwise.

Dr. Roberts admits, however, that "apart from the existence of organic disease, the conditions most frequently found associated with oxaluria, varied as they are, call for a tolerably uniform therapeutical action," so that, practically, the difference in his views, acknowledging them to be correct, requires little or no corresponding variation in treatment. In the first place, digestion should be promoted by the administration of the mineral acids in light, bitter infusions, especially when the dyspeptic symptoms point to an atonic state of the organ and of the body generally; or should the signs indicate gastric or general irritation, small doses of bicarbonate of potash in a bitter combination may prove more efficient. The patient should eat moderately of well-cooked digestible food, obtained in about equal proportions from the vegetable and animal kingdoms, carefully avoiding any articles which tend to produce flatulence. Milk should, for a time at least, be substituted for tea and coffee, and should it prove nauseating may be mixed with one-fourth its bulk of lime-water.

If the sediment is composed of minute crystals, just visible to the naked eye as reddish-brown or orange-red glittering points adhering to the sides of the vessel and to any little hairs or fibers occurring in the urine, it may be presumed to be URIC or LITHIC ACID; but a specimen should be examined as directed on p. 69, with a power of 100 or 200 diameters, when the rhombic prisms or lozenges *a*, *b*, *c*, *e* of this deposit, often with their angles rounded off into ovoids and barrel shapes, *d*, will probably be discovered. Uric acid assumes an immense variety of forms,

most of which may be traced to modifications of the rhombic system, produced, it would appear from the experiments of Dr. Ernest Sansom, by differences in the strength of the solution from which crystallization takes place, very elongated lozenges or tables, and even acicular prisms, being formed if the mother-liquid contains a large amount of acid. The well-marked yellow color of

FIG. 12.

URIC ACID CRYSTALS. (After Roberts.) × 200 Diameters.

its crystals under the microscope, as contrasted with the pure, colorless aspect of the phosphates and the extremely faint greenish tint of the oxalates, is often a valuable assistance in diagnosis when the lozenges, etc. are imperfect. According to Dr. Beale, this deposit sometimes occurs in the form of thin glistening films, and as an amorphous powder resembling urates, but in either case, after standing forty-eight hours, crystalline forms appear. The chemical characters of uric acid, which enable us

to recognize it in cases when the microscope fails at first, are, its solubility in caustic potash and soda, from which it may be precipitated in lozenges by acetic acid, and the production of a violet color (that of murexide) when the suspected sediment is treated with strong nitric acid, evaporated to dryness at a gentle heat, and a drop of ammonia added to the residue.

The amount of uric acid occurring normally in healthy urine is very small, and does not usually exceed more than ten grains per diem, although Surgeon-General Hammond (who is, however, of unusual size) found his daily average as high as 14·14 grains; yet Ranke asserts that neither sex, age, nor height and weight of body have any marked relation to the diurnal excretion of uric acid. It is found, on testing, to *decrease* in an attack of gout, and to decidedly *increase* after the arthritic paroxysm; during certain diseases and even temporary congestions of the liver, and in febrile states of the system generally.

The clinical importance of a sediment of uric acid occurring after twelve hours' standing is very slight, since it is apt to take place in perfectly normal urine, as a result of acid fermentation; but should a deposit of this substance be let fall as the urine cools, or shortly afterward (*Lithuria*), serious apprehension must be felt lest crystallization may occur in the urinary passages and give rise to all the painful and dangerous symptoms produced by nephritic and vesical calculi. Dr. Bird states that a so-called pisiform deposit of uric acid is very common in gouty persons, and occurs in little spherical masses, of a pale-yellow color, varying in size from that of small millet-seeds to that of a pea, rather, indeed, to be referred to the class of calculi than of sediments; such aggregations of crystals often produce the agonizing suffering of nephritic colic during their passage along the ureter. According to the same author, the conditions under which an excess of uric acid,

either alone or in combination with alkalies, occurs in the urine, a normal quantity of water being present, are—First, a waste of tissue more rapid than the supply of nitrogenized nourishment, as in fever, acute inflammation, and phthisis. Second, supply of nitrogen in the food greater than is required for the reparation and supply of tissue, as in excessive consumption of animal food, or, the quantity of food remaining the same, indulgence in insufficient bodily exercise. Third, supply of nitrogenized food not being in excess, but the digestive functions unable to assimilate it, as in all the varieties of dyspepsia. Fourth, the cutaneous outlet for nitrogenized excreta being obstructed, the kidneys are called upon to compensate for the deficient function, as in all or most stages of diseases attended with arrest of perspiration. Fifth, congestion of the kidneys produced by local causes, as blows and strains of the loins, or disease of the genital apparatus. Dr. Beale observes, "In chronic diseases of the respiratory organs we often meet with uric acid and urates in the urine. It is common in emphysema of the lungs, and in chronic bronchitis. In pneumonia and rheumatic fever it is often found. It is seldom absent from the urine in chorea, and very often exists in various forms of skin disease, and in cases of acute inflammation of the kidney. It is occasionally met with in diabetes. There are many cases in which the tendency to deposits of uric acid is not very easily explained. Some children are very liable to suffer from these deposits, and their appearance is accompanied by frequent desire to pass urine. In cases where this state of urine is very frequent, it is necessary for the practitioner to interfere." When deposits of uric acid occur, and especially if the patient is of a gouty tendency, he highly recommends small doses of chlorohydric acid, with pepsin, before meals, and twenty grains of bicarbonate of potash in half a tumbler of water after meals,

but mentions that in some cases the ordinary remedies appear to have no effect. Dr. Bird classifies the indications for treatment as follows: first, attention to the function of the skin; second, restoration of tone to the organs of digestion; and third, administration of remedies which act as solvents of uric acid. In regard to the first, he remarks, "I have repeatedly seen diaphoretics, warm clothing, the use of flannel, and in winter even a chamois leather waistcoat, with friction by means of a flesh-glove or hair-glove, repeatedly (in the ame case?) remove a deposit of uric acid gravel; and, in more than one instance, where even an hereditary taint existed from gouty or calculous progenitors." And he attributes the extreme rarity of calculous disorders among seamen in the navy to the kind of vapor-bath in which they sleep when crowded between-decks. To fulfill the second indication, he advises careful regulation of the bowels, by mercurial and other purgatives, and moderate doses of carbonate of potassa or soda, in infusions of gentian, columbo, or serpentaria, and the relief of gastrodynia (with or without pyrosis), by the administration of half a grain of nitrate, or one, of the oxide of silver, immediately before a meal; abstinence from large quantities of food, and, in protracted cases, from all nitrogenous diet, being enjoined; finally, as a solvent of uric acid, he recommends the bicarbonate of potassa, in half-drachm doses, three times daily, stirred up with five grains of citric acid in a tumbler of warm water, or the acetate, citrate, or tartrate of potash may be given in solution, freely diluted, or the celebrated Vichy water can be tried.

In conducting the solvent treatment of uric acid calculi, Dr. Roberts directs that the urine should be rendered decidedly alkaline, by doses of forty to sixty grains of acetate or citrate of potash, dissolved in four ounces of water, and regularly repeated every three hours, except during sleep, to avoid any return of acidity in the renal secretion. He

states that he has employed the bicarbonate, acetate, and citrate of potash, in doses of from four to eight drachms in twenty-four hours, in a very large number of cases, for periods varying from a fortnight to three months, and in no instance were deleterious effects observed; but he considers the solvent treatment "only applicable in those cases of vesical calculi in which the urine is acid, the stone not large, (and) its composition known to be uric acid, or strongly suspected to be such."

Carbonate of Lime is one of the rare sediments from human urine, although said to be quite common in that of the horse, occurring, in both cases, in the form of spherules composed of aggregated acicular crystals. It may be recognized, either when actually deposited, or introduced in the form of chalk or marble dust for purposes of deception, by dissolving with the evolution of carbonic acid gas in acetic acid.

If the deposit is whitish, and under the microscope (examined as directed on page 69) is found to consist of six-sided plates, which, when dissolved in liquor ammoniæ, are re-deposited in the same form on its evaporation, it is composed of Cystine. This substance, remarkable for containing nearly twenty-six per cent. of sulphur, is soluble in caustic potash and its carbonate, and in the mineral acids, but insoluble in carbonate of ammonia, acetic and tartaric acids, water, and alcohol. When heated on platina foil in the flame of a spirit-lamp it evolves thick white fumes of a disagreeable odor resembling garlic. According to Dr. Bird, the urine depositing cystine is generally pale yellow, of a somewhat oily appearance, having frequently the odor of sweet-brier and being of less than the normal specific gravity. Sometimes its smell more nearly resembles that of putrid cabbage, probably owing to decomposition and the evolution of sulphuretted hydrogen, and in such specimens the color changes from pale yellow

to green. The crystals of cystine are often aggregated together in the form of rosettes, and even single crystals are sometimes marked with confused lines near their centers of troubled crystallization; occasionally square prisms are found associated with the usual hexagonal laminæ. Common salt (chloride of sodium) is the only body likely to occur in urine and be mistaken for cystine; it may at once be distinguished by being readily soluble, when a large quantity of water is added.

The origin of cystine in the human body has not yet been discovered; but Dr. Roberts observes that "the close analogy of composition between it and taurine renders it not improbable that the liver is the original source of cystine, and the discovery of cystine in the livers of typhus patients by Scherer lends support to this view." It is remarkable that the tendency to formation of this deposit should be strongly hereditary, Dr. Bird referring to an instance when it appeared in three successive generations. The production of cystine seems to be connected with depression of the vital powers, especially in strumous constitutions; but, beyond the local and mechanical irritation caused by the crystals, the chief danger is apparently their aggregation into a calculus. In the treatment of *Cystinuria* Dr. Prout recommends the persistent use of nitro-hydrochloric acid, but Dr. Bird and Dr. Beale have not found this method satisfactory, and place much more reliance upon the administration of iron, particularly the syrup of the iodide, conjoined with sea-bathing, exercise, attention to diet and to the functions of the skin.

XANTHINE, XANTHIC OXIDE, or URIC OXIDE is a very rare deposit, in appearance strongly resembling uric acid, from which it may, however, be distinguished by its ready solubility in hot water and in the mineral acids. As but four or five cases in all are reported, its clinical importance is very small.

Silica, in the form of common sand, has sometimes been added to the urine by hysterical females to deceive the physician; it may be detected by its insolubility in boiling nitric acid.

Tyrosine, which occurs in some cases of disease, and especially of acute atrophy of the liver, as a deposit in the urine of acicular crystals aggregated in sheaf-like bundles or globular masses, is considered by Frerichs as an important aid to diagnosis. In cases of suspected acute yellow atrophy of the liver a few drops of the urine should be evaporated in a watch-glass nearly to dryness, and the residue examined microscopically for tyrosine; Leucine will probably also be present, generally in the form of oily-looking globules, but when pure it crystallizes in delicate needles. (See case of Leucinosis, by Prof. H. C. Wood, Jr., reported in Trans. Coll. of Physicians of Phila., *Am. Jour. of Med. Sci.*, April, 1867.)

The presence of Entozoa in the urine when passed appears to be comparatively rare in this country, although numerous cases are recorded abroad. Among the species described by Dr. Beale may be mentioned small hydatids which have escaped from parent cysts in the kidneys, also echinococci and their hooklets (the latter very characteristic) which have been detected in some cases; the Diplosoma crenata, a worm from four to six inches long, of which a single case is reported by Dr. Arthur Farre; the Strongylus gigas, which reaches a length of fifteen inches and may exist coiled up in the kidney; the Distoma hæmatobium, said to be very abundant in Egypt; and the Bilharzia hæmatobia and capensis, the latter species, as shown by Dr. John Harley, being the cause of a form of hæmaturia endemic in some parts of the Cape of Good Hope. (See Chap. IX.)

CHAPTER VII.

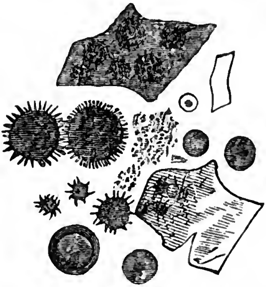
EXAMINATION OF URINE.

Substances which Float in or upon the Fluid (including Extraneous Matters).—Recapitulation and Remarks.

URINE which has been allowed to stand for about twelve hours, as directed in Chapter III. (p. 68), is occasionally found, on examination, free from deposit, and yet presenting a turbid aspect, as if some insoluble material had been separated but failed to subside to the bottom of the vessel. This appearance may be caused—first, by the presence of alkaline urates in a state of extremely minute division, which can be detected by simply warming the liquid in a test-tube, and so redissolving the solid matter; secondly, it may arise from the rapid development of Vibriones and Bacteria, which sometimes become so numerous in a few hours as to render the urine quite opalescent; they can be recognized without difficulty in most cases by microscopic examination as directed on page 103, where their pathological signification is considered; thirdly, it may have its origin in the admixture of very minute Fatty particles (that is, fatty matter in the so-called molecular state), constituting what is termed Chylous urine. Urine of this character is often of a pinkish color, from the admixture of red blood corpuscles, which may be seen on microscopic examination, and Leucocytes in greater or less abundance are always found. Doubts as to the nature of the molecules may be solved by agitating the suspected turbid urine, with about one-third its bulk

of sulphuric ether, in a test-tube, when the fatty matter, if such it is, will undergo solution. According to Dr. Roberts, there is a strong probability that chylous and lymphous urine are respectively mixtures of chyle and lymph with the renal secretion. As this interesting and remarkable affection is extremely rare in our climate, only three cases being reported by Bird, Beale, and Roberts as occurring in persons who had not resided in hot countries, it seems unnecessary to enter more fully into its details.

Fig. 13.



Urate of Soda and Films of Triple Phosphate formed on the Surface of Concentrated Urine. × 215 Diameters. (After Beale.)

The pathological ingredients of the urine which occasionally form a pellicle so thin that it floats upon the surface of the fluid, are chiefly amorphous Triple phosphate, combined with organic matter, and generally containing crystals of the triple phosphate, sometimes very minute, but exhibiting their characteristic form if sufficiently magnified. When such films are formed by rapid evaporation of the urine, they generally entangle urate of soda, crystallized in small spherical masses, from the sides of which little spicules project (Fig. 13). The so-called Kiestine, investigated by Dr. Kane, the celebrated Arctic explorer, when a student of medicine, and claimed by some to be a pathognomonic sign of pregnancy, is chiefly composed of minute oil-globules which float upon the surface of the urine, associated with crystals of triple phosphate.

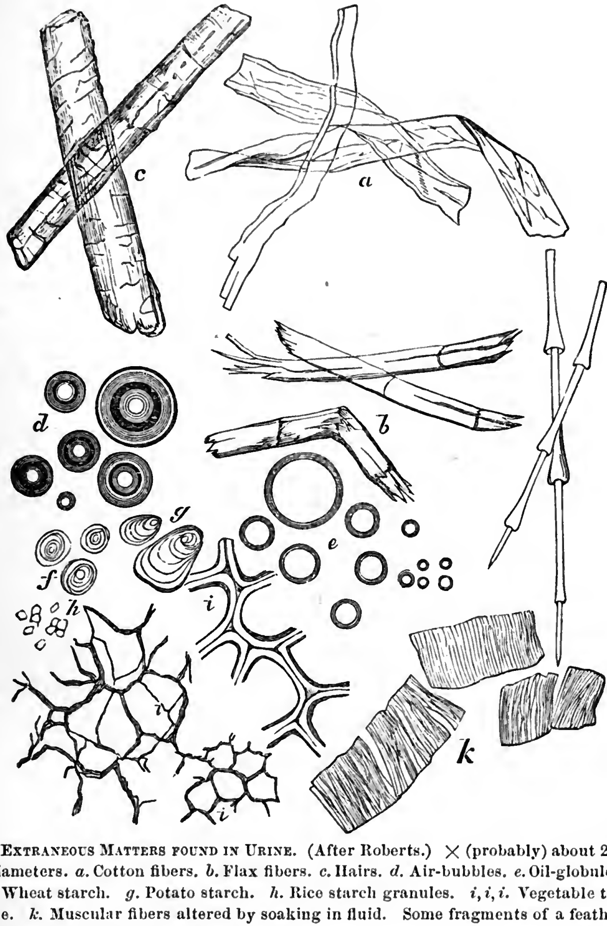
Uro-stealith is a peculiar form of fatty matter, occurring as small concretions in a single case, that of an Austrian weaver.

It is obvious that, in spite of all the precautions we may adopt for obtaining specimens of urine without admixture with foreign bodies, extraneous matters in immense variety will frequently present themselves beneath the microscope, and give rise to much uncertainty, or even sometimes to erroneous conclusions, on the part of the student. Many of these foreign bodies have been already referred to, but the importance of their recognition is so great that it seems to warrant their detailed description. Among the most common accidental impurities of urine are the various kinds of hair and wool, including human hair (Fig. 14, *c*), cat's hair, dog's hair, wool from a blanket, from cloth, and from flannel, it being remembered that all these different varieties, as well as many other foreign matters, are constantly floating in the air of almost every room of every house, and require no special and obvious exposure to admit of their entrance into the renal secretion.

Many varieties of hair and wool (*c*) are liable to be mistaken for casts of the uriniferous tubules, but may be distinguished as follows: in the first place, fragments of each are generally much longer, and larger in diameter, than tube-casts; their extremities are often fibrillated, and as it were splintered, like the broken end of a green twig, instead of being frequently club-shaped; also their color is much darker than that of the hyaline casts, and although it may approach quite closely to that of darkly granular casts, they are obviously much more homogeneous in constitution than the latter. In doubtful cases, I should advise the student to press firmly upon the thin glass cover with a mounted needle over the suspected body, as seen with a half-inch objective, when, if it happens to be a tube-cast, it will be observed to crush beneath the force applied, whilst the covering glass would probably break before a hair could be more than slightly flattened. Fragments of

colored worsted often find their way into urine, as well as into other fluids from the body, but are generally easy to recognize, occasionally affording a hint to some useful fact.

FIG. 14.



EXTRANEOUS MATTERS FOUND IN URINE. (After Roberts.) × (probably) about 200 Diameters. *a.* Cotton fibers. *b.* Flax fibers. *c.* Hairs. *d.* Air-bubbles. *e.* Oil-globules. *f.* Wheat starch. *g.* Potato starch. *h.* Rice starch granules. *i, i, i.* Vegetable tissue. *k.* Muscular fibers altered by soaking in fluid. Some fragments of a feather are figured on the extreme right.

Thus, for example, on one occasion, in examining a drop of blood from the arm of a patient, I met with a little piece of blue wool; glancing at the young man, and observing that he wore a white shirt only, I said to him, "Don't you know you are very likely to take cold by going without your blue flannel shirt? When did you leave it off?" "Only this morning, doctor," replied he, with a half-frightened air, which was exchanged for a completely astonished one when I explained how I had detected his imprudence.

Flax and cotton fibers (*b* and *a*) are among the most common impurities of urine, not only being deposited as dust from the air of chambers where linen and muslin sheets are so often shaken, but also frequently adhering to the slides and covers from the cloths used in cleansing them. They may generally be distinguished from tube-casts, which they chiefly resemble, by their larger diameter, fibrillated extremities, and somewhat striated appearance (see also Fig. 5, *a*); but the best way for the student to become familiar with their characteristics is for him to scrape off a little lint, first from a linen and then from a cotton handkerchief, upon a slide, adding a drop of water or urine, covering it with thin glass, and examining it with a power of about 200 diameters. In doubtful cases the "pressure test" recommended above may often be used with advantage.

Fibers of silk, especially if uncolored, more nearly approach tube-casts in size than any of the preceding, and indeed are not unlike some specimens of hyaline casts; they should be carefully studied by the youthful microscopist, who will here find the pressure test particularly applicable Dr. Beale states that "their smooth, glistening appearance and small diameter at once distinguish them from small portions of urinary casts, and their clear outline and regular size from shreds of mucus, etc."

Portions of feathers (see Fig. 14) from beds and pillows are occasionally met with in urine, but, as they bear no close resemblance to any of its normal or pathological ingredients, are not dangerous impurities, although often very puzzling to the beginner; it is stated that they have been mistaken for nerve-tubes; but a few minutes' study would probably fix their characters in the mind's eye so firmly as to render such an error subsequently impossible.

Fibers of coniferous wood are said to occur very frequently in the urine in houses where the floors are bare and unpainted, but are not often found, so far as my experience goes, in our large cities; they may be readily studied by cutting with a sharp knife a very thin longitudinal shaving from a piece of soft pine wood, such as a match, and examining it in fluid. Dr. Beale remarks: "Of all the extraneous matters likely to be met with in urine most calculated to deceive the eye of the observer, none are more puzzling than the short pieces of single fibers of deal. In hospitals, where the floor is uncovered and frequently swept, portions of the fibers of the wood are detached, and, being light, very readily find their way into any vessel which may be near. In fact, these fibers enter largely into the composition of the dust which is swept up. I was familiar with the appearance of these bodies for a long time before I ascertained their nature; for, although the peculiar characters of coniferous wood are sufficiently well marked, when only very small portions are present, and in a situation where they would scarcely be expected to be met with, their nature may not be so easily made out. Often only two or three pores may be seen, and not unfrequently these are less regular than usual, in which case they may be easily mistaken for a small portion of a cast with two or three cells of epithelium contained within it. I have very frequently met with these fibers amongst the

deposit of various specimens of urine which have been obtained from private as well as from hospital patients."

Starch granules (*f*, *g*, and *h*), either deposited from the air as dust, or accidentally and even purposely introduced, as particles of boiled potato, boiled rice, crumbs of bread, etc., are often to be met with in urine, and mislead the unpracticed observer. They may generally be detected by the action of solution of iodine, which produces a deep blue or purple color, except where the granules have undergone complete conversion into dextrine, which gives a brown tint with the reagent; but, to avoid mortifying blunders, specimens of starches should be carefully studied, both dry and immersed in various fluids.

Portions of tea-leaves sometimes find their way into the urine and give rise to much speculation among the inexperienced; they may generally be distinguished, after a little preliminary study of the deposit from a *tea*-pot, by their regular cellular structure and minute spiral vessels.

Milk (Fig. 16) is sometimes added to urine for the purpose of deception, but, according to Dr. Beale, may be almost always diagnosticated, by its globules, from the fatty matter of chylous urine, which is generally, if not universally, in a molecular state. Globules of sweet oil (*e*) sometimes occur in the urine of patients suffering with stricture, being derived from the catheters and other instruments employed.

As already mentioned, scratches, indentations, and minute excavations in the surface of the glass slide or cover, both clean and when filled with coloring-matter, are very liable to puzzle a juvenile microscopist; and indeed I have reason to suppose that these microscopic dirt-pits have temporarily misled very skillful observers. Their delusive character may be readily studied by rubbing bright and clean an ordinary glass slide that has for some time been in daily use for examinations of blood and

urine, and inspecting its surface with a power of about 200 diameters.

Expectorated matters (see Fig. 20), including all those substances enumerated in Chapter VIII. as possible ingredients of the saliva, and Vomited materials, among which may, of course, occur each of the different articles of food, frequently become mixed with urine, and are liable to give rise to error. In cases of doubt or suspected imposition, the precaution should be taken of having the urine passed into a clean vessel, in the presence of the physician or nurse, and immediately transferred to a freshly-washed vial and securely corked. A case recently came before the Biological and Microscopical Department of the Academy of Natural Sciences in this city, when some minute worms, supposed to be trichinæ, were found in the urine; but, on being referred to Prof. Joseph Leidy, he decided that they were specimens of the Anguillula aceti, or vinegar eel (see Chapter XIII.), probably introduced by the patient with the design of puzzling the doctors.

The questions to be solved by examination of the urine form so large a part of the problems submitted to the microscopist, that, although the investigation of deposits from the renal secretion has been so fully discussed in the preceding chapters, I am confident that a brief review of the subject will prove useful to some who may consult these pages, more especially if, as sometimes unavoidably happens, their researches must be hurriedly made, owing to the pressure of other engagements.

In the examination of urine, then, we may find that—

1st. It lets fall a distinct deposit.

A. This deposit is Light and Flocculent.

a. It occurs in Albuminous urine, that is, one yielding a coagulum on testing with heat and nitric acid (see p. 68).

α. On microscopic examination (p. 69)

CASTS of the uriniferous tubules (transparent or granular cylinders, $\frac{1}{500}$ to $\frac{1}{1000}$ of an inch in diameter), Granular, Epithelial, or Hyaline (p. 70), are found. *The patient is suffering from Bright's disease of the Kidney, whose form and stage are to be diagnosticated as directed on page* 82 *et sequitur.*

β. Under the microscope, RED BLOOD CORPUSCLES (non-nucleated globules $\frac{1}{3500}$ of an inch in diameter, p. 121), mixed with more or less mucus, can alone be distinguished. *The affection is Hæmaturia.* (See Chapter VI., p. 125.)

γ. LEUCOCYTES (nucleated corpuscles averaging $\frac{1}{2500}$ of an inch in diameter, p. 114) (in this albuminous liquid, pus corpuscles) are present without any other ingredients. *These indicate inflammation of some portion of the urinary tract* (*Nephritis, Cystitis, etc., for whose diagnosis see* Chapter V., p. 117).

b. The deposit takes place in urine which is not albuminous, yielding no coagulum on testing with heat and nitric acid.

a. On microscopic examination LEUCOCYTES (nucleated cells averaging $\frac{1}{2500}$ of an inch in diameter), epithelial cells from the bladder, and perhaps long, twisted, transparent mucous casts of the uriniferous tubules, are visible. (See Chapter IV., p. 96.) *When abundant, these indicate an excessive secretion of mucus, the result of irritation of the urinary tract* (p. 99).

β. The microscope shows SPERMATOZOA (bodies resembling tadpoles, with very elongated tails). (See Chapter IV., p. 100.) *These signify coitus, and, if very numerous and persistent, Spermatorrhœa.*

γ. FUNGOUS GROWTHS (generally in the form of cellular bodies from $\frac{1}{4000}$ to $\frac{1}{10000}$ of an inch in diameter, often arranged in chains, and either still or in active vibratile motion) are detected beneath the microscope. (See Chapter IV., p. 103.) *Their pathological significance requires further study* (p. 104).

δ. In rare cases, hyaline and pale granular TUBE-CASTS may be detected in non-albuminous urine (p. 68). *Bright's Disease* (p. 74).

B. This deposit is dense and opaque, occupying considerable bulk.

a. On testing with heat and nitric acid, the supernatant fluid is found free from albumen.

α. The deposit let fall is seen under the microscope to be simply granular. (See Chapter V., p. 107). It consists either of amorphous URATES or PHOSPHATE OF LIME, the former of which dissolve readily on heating the fluid, while the latter does not. (See p. 109.)

β. The sediment is composed of microscopic crystals, triangular prisms and their derivatives (see Chapter V., p. 110). TRIPLE PHOSPHATE OF AMMONIA AND MAGNESIA, *Phosphuria* (p. 111).

b. The reactions of the urine with heat and nitric acid show the presence of albumen.

α. The microscopic investigation proves the existence of LEUCOCYTES (nucleated cells $\frac{1}{2500}$ of an inch in diameter) only. (See Chapter V., p. 114.) *Nephritis, Pyelitis, Cystitis, etc.* (p. 117).

β. Crystals of TRIPLE PHOSPHATE (p. 110), associated with LEUCOCYTES, are discovered. *Chronic cystitis, often dependent on calculus, is generally present* (p. 112) *if these are abundant.*

C. This deposit appears to the naked eye granular or crystalline, occupying only a small bulk.

a. The urine is found to contain albumen, under the tests of heat and nitric acid.

α. The microscope proves the presence of RED BLOOD CORPUSCLES (non-nucleated cells $\frac{1}{3500}$ of an inch in diameter, p. 121). *Hæmaturia is indicated* (see p. 125).

β. CANCER CELLS (irregular, caudate, and oval cells with large nuclei, p. 126) are seen under a power of 200 diameters. *Carcinoma of some portion of the urinary tract probably exists; but great care must be taken to avoid mistaking epithelial for cancer cells* (p. 127).

γ. Microscopic examination shows "TUBERCLE CORPUSCLES" (non-nucleated, granular, oval bodies, about $\frac{1}{2000}$ of an inch in length, p. 128) to exist in the deposit. *Tuberculosis of the kidney may be suspected, according to some authorities* (see p. 128).

b. The reactions on testing as above prove the urine to be free from albumen.

α. Under the microscope the sediment is seen to consist of OXALATE OF LIME (bril-

liant octahedral crystals, presenting the appearance of squares marked with diagonal crosses, or more rarely in the form of dumb-bells). *Oxaluria* (see Chapter VI., p. 129) *exists.*

β. The deposit is found to be composed of URIC ACID (yellowish crystals, lozenge-shaped, oval, barrel-shaped, etc., p. 132). *Lithi-uria (see Chapter VI., p.* 134) *is present.*

γ. In rare cases the deposit may consist of microscopic spherules and dumb-bells, soluble with effervescence in acetic acid. CARBONATE OF LIME (see p. 137).

δ. Occasionally hexagonal crystals, deposited in the same form from their ammoniacal solution, are seen on examination with the microscope. These are CYSTINE (see Chapter VI., p. 137). *Cystinuria.*

ε. If the sediment resembles uric acid, but is soluble in hot water and in the mineral acids, it is composed of XANTHINE. (See p. 138.)

ζ. Sheaf-like bundles or globular masses of acicular crystals should lead us to suspect the presence of TYROSINE and LEUCINE (p. 139), and indicate *Acute Atrophy of the Liver.* (Frerichs.)

η. If hydatids or other ENTOZOA are found, consult Chapter VI., p. 139.

2d. It becomes turbid without letting fall any distinct deposit.

A. This turbidity disappears on warming the fluid. *The solid matter consists of amorphous urates* (p. 140, *and Chapter V.*, p. 107).

B. The urine remains cloudy during the application of heat.

a. Microscopic examination reveals VIBRIONES and Bacteria (under a power of 200, seen as very delicate lines from $\frac{1}{2000}$ to $\frac{1}{10000}$ of an inch in length, constantly in rapid motion, p. 104). *Putrefactive fermentation.*

b. Under the microscope the opacity is seen to be due to multitudes of molecules, too minute for measurement. *Chylous Urine* (see p. 140).

3d. It presents a delicate FILM floating upon its surface.

A. Microscopic examination shows the triangular prisms of Triple phosphate (pp. 110 and 141), usually associated with granular phosphates and spherules of urate of soda. *Phosphuria.* (See Chapter V., p. 112.)

B. Numerous small oil-globules are seen under the microscope, associated with crystals of triple phosphate. *So-called Kiestine, by some considered an aid in the diagnosis of Pregnancy* (p. 141).

It must not be forgotten, in making use of the above table for investigating the urine, that two, three, or more of the conditions described may exist in the same specimen, and each tend to obscure the characteristics of the other: thus, for instance, a sample of albuminous urine, which has been kept two or three days in hot weather, might be so opaque from the development of Bacteria that no coagulum could be detected on heating, and also let fall so abundant a deposit of amorphous urates that any tube-casts which exist would be entirely concealed. In such a case you cannot eliminate the consideration of Bright's disease until you have carefully filtered the urine previous to

testing for albumen, and also examined a specimen upon a slide sufficiently warmed to induce the fluid to redissolve the urates. Bearing in mind, however, the danger of being misled by these accidents, I believe this scheme, with the limitations and exceptions detailed in the preceding chapters and referred to by the pages on which they occur, may be trusted as a safe general guide to the indications afforded by the renal secretion.

In all doubtful cases the student should carefully consult the remarks upon extraneous matters, commencing on p. 142.

CHAPTER VIII.

EXAMINATION OF PUS, MUCUS, SALIVA, AND MILK.

In no department of microscopy have more important discoveries been made within the last decade than in regard to the origin of Pus, the corpuscles of which, for whose diagnosis from mucous and white blood globules elaborate directions were formerly given, are now proved by the ingenious experiments of Prof. Cohnheim, of Kiel, to be absolutely identical with the last two histological elements. As some experiments of my own, in which I was apparently the first to demonstrate the true origin of the salivary corpuscles, strongly corroborated Prof. Cohnheim's investigations, by independent and converging evidence obtained in a different line of research, I became, as far as I am aware, the earliest advocate of the doctrine in this country (*Pennsylvania Hospital Reports*, January, 1869), and in an article in the January number of *The American Journal of the Medical Sciences*, for 1870, have endeavored to elucidate, by its aid, the true pathology of Bright's disease. The following brief review of the subject is extracted almost verbatim from the latter paper:

"As, however, the important advance in pathological science, to which I have alluded, is still spoken of in this country under the title of 'Cohnheim's alleged Discovery,' it may not be unnecessary to advert briefly to its merits and the testimony which supports it. Dr. Cohnheim, as the readers of this journal are aware (see number for

October, 1869, pp. 549–552), first published his theory of Inflammation, and detailed the original and ingenious experiments from which it was built up, in a leading article in *Virchow's Archives* for September, 1867, which soon attracted everywhere the notice of histologists. According to Cohnheim, the process of pyogenesis consists—first, in a partial interruption of the flow of blood, by which the red corpuscles move more slowly through, or almost block up, the capillaries, while white globules adhering to the parietes of the vessels arrange themselves in a layer upon this inner surface of the walls; and, second, in the 'wandering out' of these white blood cells through the stomata, demonstrated by Recklinhausen in the walls of the finer blood-vessels, by virtue of that amœboid movement (see Fig. 15) which is one of the most remarkable attributes of the white blood corpuscle, and so aptly illustrated by an English commentator on Prof. Huxley's great lecture upon Protoplasm, when he explains the process of an amœba taking a minute Diatom into its substance for food, by comparing it to a lump of dough growing of itself gradually around an apple to make an apple-dumpling: the white blood corpuscles which have thus wandered out then constitute with exuded serum that yellow fluid so long known under the name of pus, and hitherto generally supposed to be a product of the breaking down of tissue. In support of this doctrine, experiments upon frogs and rabbits paralyzed by woorara are described, in which, the mesentery of the animal being exposed and spread out upon the field of the microscope, multitudes of white corpuscles were *seen* in all stages of transit from the interior to the exterior of the vascular walls, in which latter position they constituted ordinary pus globules.

"Of course such a novelty in medical science has met with numerous assailants, among whom the most prominent seems to be Prof. Kolman Balogh, of Pesth, who, in

an article in *Virchow's Archives* (Erstes Heft, Band xlv. S. 19, u. s. w.), asserts that in spite of the most prolonged and careful attention not once could he see the transit of the white blood cells through the stomata in the vascular walls, which he thinks, if they exist, are such minute pores that they can give passage only to fluids. His observations are, however, sharply commented upon by Dr. A. Schklarewski, of Moskow, in the following volume of the *Archives* (Band xlvi., Hft. 1, S. 116), and Cohnheim's experiments appear (*Transactions of Pathological Society of London*, vol. xix. p. 467) to have been repeated before the London Pathological Society in April, 1868, by Dr. H. Charlton Bastian, of London, with entire success. In our own country, Lieutenant-Colonel J. J. Woodward, Surgeon, U.S.A., stated during a lecture at the Philadelphia College of Physicians, May 31, 1869, that the experiments of Cohnheim had been tested under his direction in the Surgeon-General's office at Washington, and that he had found the description of phenomena singularly accurate, the observations on frogs being fully corroborated, as far as they had time to repeat them, in every particular; and Dr. William F. Norris, of this city, but for some years past residing in Germany, in an article now in press, detailing observations made, chiefly on the corneæ of frogs, in conjunction with Prof. Stricker, of Vienna, while maintaining that some of the corpuscles of pus originate in the proper cells of the tissue, admits as indubitable that many are in reality white blood globules which have made their way through the walls of the vessels, as Cohnheim describes.

"It has been urged, however, by some assailants of this doctrine, that even admitting, for the sake of the argument, Cohnheim's views on inflammation to be correct as regards the inferior animals, upon which his experiments were tried, there is no proof that the same ignoble process

of suppuration affects man, a creature of such far higher attributes; but on this point I trust that my own experiments, above referred to, will be found conclusive. By diluting a drop of my own blood upon a slide, with pure water introduced at the margin of the thin glass cover, and thus reducing the liquor sanguinis to the specific gravity of the saliva, I found it quite possible to watch every step of the change, in which by mere distention the white blood cell is converted into the salivary corpuscle, with its one, two, or three nuclei, its actively revolving molecules confined by a cell-wall of exceeding tenuity (see Fig. 10), capable of presenting all the phenomena of deep-staining of the nuclei with the entire cessation of movement on the addition of aniline dye. In like manner, when the liquor muci and liquor puris are similarly diluted their corpuscles are also seen for the most part to be converted into salivary globules; and I infer therefore that we may regard the strong presumption afforded by Cohnheim's experiments upon the rabbit as established into a fact, and conclude that most (at any rate) of the corpuscles of *human* pus are simply white blood cells which have wandered out through the vascular walls.

"But, interesting as these researches are from a scientific point of view, it is only as they can be applied to diseased states of the human organism that they become of real importance to the physician; and my object in the present paper is to make some practical deductions in regard to the congestive and inflammatory processes undergone by the kidneys during the course of Bright's disease."

From the efforts now being made to maintain the unproved and unprolific statements of Addison (1841) and Waller (1846) as establishing valid claims to priority in this important discovery,—viz., the origin of pus in the migration of white blood cells through the walls of the blood-vessels by amœboid movement,—it would seem that

the fact itself is hardly considered any longer even *sub judice;* indeed, the contest in regard to the doctrine, with some of its strongest opponents, appears to be resolving itself into a controversy whether all the pus globules are white blood corpuscles or whether some of the former have their origin in the proliferating proper cells of the tissue in which suppuration takes place, as long taught by the great Berlin pathologist.*

It is obvious that the changes which this theory of the origin of pus will produce in our views of the process of inflammation, are so extensive and wide-spread that, when fully accepted, whole departments of pathology must be modified in accordance with its teachings; and it seems probable that we enjoy as yet only a faint glimmer of the flood of light which it is destined to throw upon many obscure points in medicine and surgery. In the preceding chapters I have endeavored to make a few of its most obvious applications to the phenomena of irritation in the urinary apparatus, and I trust that other students of microscopy may be induced to enter also upon the broad field thrown open to their labors by Prof. Cohnheim's discovery.

In examining a specimen of fluid supposed to be or to contain Pus, a minute drop of the liquid may be placed upon the slide, and if very thick and creamy, as in the so-called "laudable" pus, should be diluted with a small quantity of syrup or glycerin and water, of the specific gravity of blood serum (see p. 37), before being covered with a thin glass; because, if this precaution is not taken, so many of the pus corpuscles overlie each other in the field of view that it becomes very difficult to make out their individual characteristics. The slide thus prepared is then

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* For further evidence in favor of Cohnheim's views, see observations of MM. Vulpian and Hayem, Ranking's Half Yearly Abstract, July, 1870, p. 35 (from Gazette Hebdomadaire, No. 7, Feb. 1870).

to be transferred to the stage of the microscope, and may be examined with a power of 200 to 1200 diameters. As stated on page 115, the size and general appearance of the pus globules will vary greatly, according to the specific gravity of the liquid in which they float; but in ordinary laudable pus, diluted, *but not thinned*, as above directed, the corpuscles have a diameter of from $\frac{1}{3000}$ to $\frac{1}{2500}$ of an inch, are generally quite spherical, and present a finely granular or tuberculated surface, of a grayish-white color.

In regard to the remarkable amœboid movements (see Fig. 15) of the pus corpuscles, Dr. Beale observes that, for examination, "They should be obtained from a mucous or other surface at the time that they are *growing and multiplying.* Pus, as usually examined, consists of *dead*, not of *living*, *corpuscles.* These are *spherical*, as generally represented in books, and many have a sharp, well-defined outline, owing to coagulation having occurred upon the surface. Thus the so-called membrane or cell-wall of the pus corpuscle has resulted. A cell membrane may always be formed artificially by exposing the surface of a mass of albuminous material to the influence of a reagent, or to conditions which are known to effect the coagulation of albumen. The best specimens of pus for studying vital movements may be obtained from the urine in some cases of *chronic inflammation of the bladder.* Not uncommonly in this affection the urine contains very little solid matter, and the pus corpuscles retain their vitality although immersed in it for many hours after the urine has been removed from the bladder. So far from the corpuscles being spherical, as usually figured and described, in many specimens not a single corpuscle of this form is to be detected. Every corpuscle exhibits little 'buds,' 'offsets,' or protrusions at every part of its circumference, and attentive examination even under moderate magnifying powers will convince the observer that the corpuscles are slowly undergoing

alterations in form. The movements are very remarkable." (Microscope in Practical Medicine, p. 63.) I propose to consider the subject of the amœboid motions of Leucocytes, as well as the proofs (for such they appear to me) of the existence in these bodies of a cell-wall and well-defined nuclei, in the next chapter, having introduced the above extract here because of its more intimate connection with the present subject. The recognition of this movement is very important in the diagnosis of Leucocytes from small epithelial cells or their isolated nuclei, and of course, viewing the "different" corpuscles as identical, it is by no means necessary for the student to wait for some suitable case of chronic cystitis, as he can at any time study and become familiar, with the remarkable movements of so-called pus corpuscles in a drop of blood from his own finger, examined upon a slightly-warmed slide.

The bodies which the young microscopist might mistake for Leucocytes are, as intimated above, small, rounded epithelial cells, nuclei of epithelial cells, so-called tubercle corpuscles, the cellular elements of certain morbid growths, the spores of torula and other fungi, and in the urine granules of urates and of carbonate of lime. When the amœboid movement is visible, that alone is sufficient for diagnosis; but in their motionless condition some other mode of detecting them is requisite, and this is supplied by their varying action with reagents. A favorite test for the "pus corpuscle" with the older authorities was acetic acid, on the addition of which, according to Golding Bird (On Urinary Deposits, p. 292), "the interior of the particle becomes visible and is found to be filled with several transparent bodies or nuclei. * * * Hence pus is usually considered a regularly organized body, consisting of a granular membrane enveloping transparent nuclei; being, in fact, a nucleated cell." I have found, however, that this distention of the cell-wall, rendering visible the

contained nuclei, can often be more satisfactorily shown to a student if, instead of acetic acid, solution of aniline be introduced at the margin of the cover (see p. 45); this reagent strongly colors the nuclei, while tinting the delicate cell-walls very gently, and thus brings the characteristics of the Leucocytes clearly into view. By this means they may be distinguished from the nuclei of epithelium, which, being composed entirely of "germinal matter," become completely stained of a deep red; from small epithelial cells by frequently exhibiting two or three nuclei, while epithelium, except in very rare instances, shows but one; from tubercle corpuscles, which, as a rule, present no well-marked nuclei; from the spores of fungi, which, generally, do not possess nuclei; and from homogeneous granules of urates and carbonates. Sometimes the only way of diagnosticating pus globules from other cells, as of certain morbid growths, is to add water very gradually at the edge of the covering glass and then under a power of at least 500 watch carefully for the commencement of the molecular movement (see p. 157) so characteristic of the *salivary corpuscular* form (Fig. 10) of the Leucocyte, and, as far as my experience goes, occurring in no other cellular element of the human body; although occasionally I have seen a segment of the membranous envelope of an epithelial cell raised up from the substance of the latter into what looked like an exceedingly delicate bulla, apparently by the endosmosis of fluid beneath it.

As stated above, the Leucocytes of pus present at first exactly the same appearance as those of the blood, but after a time, and under certain conditions not yet clearly made out, they appear to undergo fatty degeneration, and become filled with oil globules, sometimes measuring $\frac{1}{10000}$ of an inch across, after which change I have never seen them exhibit active amœboid movements. Without pretending to decide the mooted point in surgical pathology,

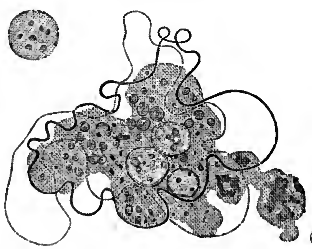
as to whether Pus, *as Pus,* can be absorbed, I may state that my observations incline me to believe that Leucocytes which have made their way out of the vessels can probably sometimes re-enter by the same amœboid movement, provided this fatty degeneration has not taken place. The practical results of treatment of abscesses by pressure applied early, seem to confirm such a view. In most specimens of pus are occasionally to be seen granular corpuscles about $\frac{1}{1200}$ of an inch in diameter, which seem as if they might be formed by the coalescence of four or six ordinary Leucocytes, and, as I think these are rare in mucus, they may sometimes aid us in diagnosis. According to Hughes Bennett, in what is called scrofulous pus "the corpuscles, instead of being round and rolling freely upon each other, are misshapen and irregular, and on the addition of acetic acid the granular nuclei are found to be ill formed or absent;" while Gluge (Pathological Histology, Prof. Leidy's translation, p. 48) says cachectic pus corpuscles "are soft, liquefying on the slightest pressure, gray, irregular, and not sharply defined, but nevertheless their nucleoli are distinguishable. * * * In sanies sometimes Vibriones are found." Many years since, Donné announced the discovery of immense numbers of Vibriones in the pus of chancres, an observation which I have recently confirmed in a marked case. The organisms were very active and vigorous in their movements, but at the same time exceedingly minute, requiring a power of about 1200 for their examination.

As microscopic observation of any fluid is quite powerless to determine, alone, whether the Leucocytes detected are those of mucus or of pus, other methods, such as the ones directed on pp 96, 114, must be brought into requisition; but if the quantity of the specimen at our disposal is very minute, it may be altogether impossible to decide the question. Of course, when we can obtain an accurate history of the case, and especially if we remove the fluid

ourselves from a patient and can thus be sure that it has not proceeded from any part covered with mucous membrane, we may feel confident of its nature; but in examples where a small amount of fluid apparently purulent flows from a mucous surface, I am not aware of any means by which we can decide positively whether it be mucus or pus, unless the occurrence of the very large sextuple cells referred to on page 162 should, on further investigation, prove characteristic. According to the theory already adopted, the exudation of pus at any point indicates that some obstruction to the circulation in the adjacent blood-vessels has occurred and been sufficient to allow the corpuscles to migrate through the stomata of the vascular walls. The importance of pus cells in the urine has been already discussed in Chapter V., p. 116 *et seq.*

The examination of Mucus presents no special difficulties, and is to be conducted in a manner similar to that advised in the preceding pages for the investigation of pus, the Leucocytes (Fig. 15) being identical. The great difference between these two fluids seems to consist in that the liquor muci is a *secretion*, which, having been acted upon by the "germinal matter" of the epithelial cells covering the basement mucous membrane, is not albuminous, and consequently gives no coagulum with heat and nitric acid; while the liquor puris is an *exudation*, which, being the blood serum perhaps driven between the scales of the integument or hurried through the cells of a mucous membrane without allowing time for

Fig. 15.



Mucous Corpuscle undergoing Amœboid Movement. × 2800 Diameters. (After Beale.) "From the mucus of the throat of a man in health; showing the different forms assumed by the living mass within a minute."

their specific action, by a *vis a tergo*, contains albumen that may be recognized by appropriate tests. Directions for special examination of mucus in urine have already been given on p. 96, while for that of intestinal, vaginal, and uterine mucus the reader is referred to Chap. XII.

The investigation of SALIVA has already been detailed, and its minutiæ described as a subject for practice by novices in the art of microscopy, so that I can hardly give a more particular account of the exact method for detecting its normal constituents than the one upon page 47.

The epithelial cells of the mouth, which are almost always present more or less abundantly in the saliva, are of the pavement variety, arranged in several layers, those in the deeper strata being rounded, while the more superficial are flattened and polygonal, each containing a single nucleus about the size of a red blood globule, but oval in form and unlike the blood disks, becoming deeply colored on the addition of a weak Aniline solution. Under high powers the older epithelial cells may often be seen filled with oval and elongated bodies, closely resembling Bacterida, especially in febrile states of the system when the tongue is coated with a thick "fur." As observed by Von Düben, the brown tint of the coating in typhus and similar diseases is caused by blood derived from the fissures of the dried mucous membrane.

The salivary corpuscles, whose true nature I seem to have been the first to point out, present (as described in my paper, Identity of the White Corpuscles of the Blood with Salivary Pus and Mucous Corpuscles: Pennsylvania Hospital Reports, Philadelphia, 1869) under a power of eleven hundred diameters "the appearance of perfect spheres varying from the $\frac{1}{1400}$ to the $\frac{1}{2500}$ of an inch in diameter, each having a very transparent but beautifully defined cell-wall of exceeding tenuity, which incloses from one to four almost equally trans-

parent nuclei of a circular or oval form, whose diameters range from $\frac{1}{3000}$ to $\frac{1}{4000}$ of an inch. These nuclei are situated sometimes centrally, but more commonly near one side of the corpuscle, and the cavity between the margin and the cell-wall is generally filled with from 25 to 50 molecules not more than $\frac{1}{20000}$ of an inch in diameter, whose characteristic is that of constant and rapid motion. Some of these molecules seem to be elongated into an oval or hour-glass form; but the activity of their movements renders it difficult to ascertain this with precision. In my observations these corpuscles have appeared to enlarge and become flattened from the pressure of the glass cover as the stratum of liquid beneath became thinner from marginal desiccation, so that usually in the course of an hour or so they burst and discharge about one-fourth of their contents, when two, three, or more of the molecules swim away, continuing their revolving movements until they pass out of view; the other granules outside and those remaining within the cell become in a very few seconds entirely stationary. If a solution of aniline red of the strength of one grain to the ounce of distilled water be allowed to penetrate at the margin of the cover, the nuclei of the salivary corpuscle are readily stained of a bright crimson and are thus exhibited with beautiful distinctness; the dye appears, however, to exert an immediate influence upon the movement of the molecules, as I have rarely been able to find cells in which they continued to move after the nuclei became at all colored."

From my experiments as detailed in the same article, p. 253, and briefly described on p. 157 of this chapter, I conclude that, "Tracing now the white blood corpuscle from its condition of irregular outline and amœbaform movement as observed in serum and in heavy urine when the circumambient fluid approaches the density of 1028, through its rounded form with slightly more distinct nuclei

in the liquor puris and in urine of lower specific gravity, we find that immersed in a rarer liquid approximating to the mean density of the saliva (1005) it has an accurately spherical outline, is more than twice the magnitude, and contains a number of minute, actively moving molecules, thus exactly resembling in all sensible characters the true salivary corpuscle; and it therefore seems reasonably certain that the blood, under the appointed nervous influence, congesting the buccal mucous membrane and associated glands, moves slowly enough through their capillaries to allow some of its white globules to penetrate the walls of the vessels, as they do those of the frog's mesentery in Cohnheim's experiment (*Virchow's Archives*, Band xl., S. 38 *et seq.*), which, under the influence of the rarer saliva expanding them and setting free to move their contained molecules, constitute the bodies so long known to histologists as the corpuscles of the salivary fluid."

Among the abnormal ingredients of the saliva, perhaps indicating disease of the mouth and fauces, one of the most common is the Leptothrix buccalis, which, although to be found in the saliva of most persons, even in good health, appears, when allowed through neglect of cleanliness to grow very luxuriantly, to inflame and loosen the gums at their junction with the teeth.

The spores and mycelial filaments of Oidium albicans often occur in the saliva of persons suffering from Aphthæ; and, according to some authorities, this disease, so especially common in infants and in feeble adults, essentially consists of a development of the fungus upon mucous membranes of the mouth and fauces, whose vitality has become impaired. According to Von Düben, in order to detect this parasite the aphthous patch should be scraped with a scalpel, a portion of the whitish membrane placed upon a slide, moistened with a drop of liquor potassa, covered with thin glass, and examined with a power of

from 200 to 800 diameters. The liquor potassa renders the epithelial cells very transparent, but does not affect the vegetable structures, so that the oval and rounded spores and mycelial threads, somewhat resembling those of the Achorion Schönleinii (Fig. 26), can be very readily distinguished with the aid of the microscope. This author considers that "the diagnosis of aphthæ from other diseases of the oral cavity is unattended with difficulty." "Coagulated caseine may present some striking resemblance to aphthæ, but its removal from the mouth is sufficient to solve all doubts. On the other hand, true aphthæ on the tongue, if not well developed, may mislead to the supposition of their being an ordinary lingual coating. An early diagnosis being of great practical moment, in all cases of doubt the microscope should be promptly resorted to." In regard to the origin of the fungus, he remarks:* "Ed. Martin, of Jena, observed exquisite aphthæ in the vagina of a pregnant woman, who confessed that her lover (a miller by trade) had introduced his finger, which was covered with flour-dust. The infection had consequently occurred in a similar manner as in infants who depend on mealy nutriment. It may happen that aphthæ and forms of stomatitis simultaneously occur in a patient, but they have no etiological connection, and do not depend on each other."

In the treatment of aphthæ, Dr. Aitken recommends borax dissolved in glycerin and rose-water, creasote, vinegar, alcohol, and, in bad cases, chlorate of potash, with the pernitrate of iron internally. He quotes Dr. Jenner as stating that "in cases where parasitic vegetable

* This remarkable case suggests the important lesson that all farinaceous aliments intended for young infants should be thoroughly cooked, in order to destroy the germs of oidium and other fungi which may produce or aggravate aphthæ, gastritis, diarrhœa, etc.

productions abound, the application of a solution of *sulphite of soda* (ʒj to ℥j of water) removes the lesion in twenty-four hours."

Still later writers, as, for example, Prof. Bamberger (*Virchow's Archives*), confirm the view that the development of Oidium albicans upon the mucous membrane of the mouth, pharynx, etc. is the essential cause of aphthæ, which hence becomes a purely local disease. Prof. J. E. Garretson (Diseases and Surgery of the Mouth, Jaws, and Associated Parts, Phila., 1869), one of the most recent authorities upon the subject, maintains, however, on page 601 of his exhaustive treatise, that "Oidium albicans is not a disease, is not aphthæ, neither is it the expression of disease; it is merely a fungous growth, accidentally associated with a soil and circumstances favorable to it as a habitat. Aphthæ is, without doubt, the expression of a cachexia, and is not likely to be a merely local disease; neither, I conceive, is it possible for the fungus to be peculiar to a sore, as a something specific. * * * The microscopist, if I may be allowed to suggest it, has in his examinations and conclusions accepted the accident and overlooked the true disease." Perhaps the evidence at present accumulated is not sufficient to establish the fungous origin of aphthæ; yet, without claiming any actual value for the analogy as a proof, it is interesting to note here that the editors of the Micrographic Dictionary remark, in regard to the Oidium Tuckeri (the *aphthæ of the vine,* if I may be allowed to use such an expression), "There can be no doubt whatever in the minds of those who have watched the development and progress of the vine fungus that it is a *cause* and *not a consequence* of the 'murrain;' still there are various curious circumstances connected with it not at all understood. * * * The application of sulphur appears to arrest the growth." Furthermore, in view of these various facts, it seems wise to treat aphthæ

(as well as sundry zymotic diseases), when other therapeutic agents fail, more energetically and hopefully with the great parasiticides, sulphurous acid, arsenic, quinine, tincture of iron, carbolic acid, etc., even without admitting their fungous origin as fully proved. But the whole question of parasitic diseases is daily becoming of greater and greater interest, and the reader is referred to Chapters IX. and XIII. for some further remarks upon the subject.

The nature of the deposit called "tartar" upon the teeth was for a long time a mooted point among scientific observers, but, by the aid of careful microscopic investigations, has now been finally settled.

Herr Shrott, dentist, of Mühlhausen, in an interesting paper on "The Inhabitants of the Mouth and the Teeth" (translated for the *Dental Cosmos*, vol. xi. No. 1, p. 19), observes, "The tartar is also not formed by precipitate, as by precipitate I understand the separation and the deposition of dissolved hard bodies in any fluid. But the tartar is formed by cultivation, little by little; it begins at first on the places where we have the smallest change of substances,—under the posterior portion of the enamel of the incisors, or between the molars, especially where we find a decayed tooth, which prevents the mastication on that side. These places are also the true places of meeting for the infusoria: here they remain the longest time, obtain their highest age, die, and their limy remnants interlace with epithelial cells, parasites, remains of food, slime, and secretion of saliva, and form in this manner the tartar of the teeth." Among the microscopic inhabitants of the oral cavity this author enumerates spirillæ, very abundant in decayed teeth; amœbæ and monads, often found beneath artificial sets of teeth which have not been cleaned for a long time; and denticulæ or Protococcus dentalis, very minute organisms, occurring in great numbers in carious dentine.

The False membrane of Diphtheria is considered by some authorities to be composed of a peculiar exudation, which, forming a favorable nidus for the development of fungi, is often the seat of cryptogamic growth, whilst other writers maintain that the fibrinous material is only poured out in consequence of the irritation set up by a parasitic formation ramifying between the epithelial layers of the mucous membrane. Thus, for example, Dr. Beale remarks: "There is nothing very distinctive in the exudation effused upon the surface of the mucous membrane of the fauces in cases of diphtheria. It consists, as is well known, of a white, soft membrane, varying considerably in thickness. Under the microscope this is found to be composed of a more or less transparent viscid substance, about the consistence of mucus, and exhibiting the striations and wavy lines always seen in this material. Sometimes the lines are so regular as to give to the specimen a delicately fibrous appearance. Entangled in this are found,—*a*, cells of scaly epithelium from the mouth ; *b*, a number of small, transparent, round or oval particles, resembling those found in the mucous follicles and in the deepest layers of epithelium. * * * The small cells pass into pus corpuscles, and where the case is severe and the power of the patient much reduced the number of these pus-like cells is very great."

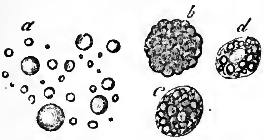
According to M. Vogel and Dr. Laycock, the irritation of the mucous membrane which gives rise to exudation is caused by the parasitic fungus, Oidium albicans, which fixes itself upon the mucous membrane of the fauces. M. Empis, who has carefully investigated the microscopic appearances, asserts, however, that the former of these gentlemen has evidently confounded under the term *diphtherite* all the pseudomembranous exudations, without examining into their nature or characters, for this parasite is not found in the true diphtheritic or fibrinous exudations, but only in those of *muguet.* Dr. L. Letzerich,

a recent contributor to *Virchow's Archives* (Band xlv., S. 333), concludes from a series of observations he has carried on, that the fungus (which he figures) producing diphtheria "belongs to the Hyphomycetes, the family of the Cladosporium, the species Zygodesmus," and, in a paper in the following volume of the *Archives*, declares that from his two works on Diphtheria "it is undoubtedly deduced that primary epidemic diphtheria is caused by a fungus whose spores (*contagium vivum*) can carry the disease to other individuals."

The examination of MILK from the human mammæ may occasionally assist in diagnosis, first of blows or contusions of the breast, and of incipient mastitis; and, second, by pointing out the cause of obstinate diarrhœa in the infant while nursing, should the milk be unsuitable in its character. A drop of milk recently drawn from the breast should be placed upon a slide, covered with a thin glass, and examined with a power of 200 to 400 diameters. According to Von Düben, milk is composed of plasma, innumerable spherical opaque and light-refracting fat granules, and fat drops and milk globules containing the former in an investment of what is probably caseine (Fig. 16, *a*). Van Bueren, Kölliker, and other observers agree that—first, "The milk globules generate in the epithelial cells of both the lacteal ducts and terminal vesicles, but chiefly in the latter; second, in perfect milk secretion both cell-walls and contents of the milk globules dissolve and join the plasma; third, in colostrum this metamorphosis is not perfect; fourth, the colostrum corpuscles generate probably in the old epithelium of the lacteal ducts." The examination of healthy milk from the human female shortly after childbirth reveals, in addition to an abundance of milk and oil globules, varying in size from the scarcely visible molecule up to the $\frac{1}{1500}$ of an inch in diameter (Fig. 16, *a*), numerous colostrum corpuscles,

sometimes attaining a diameter of $\frac{1}{800}$ of an inch, and strongly resembling other epithelial cells, as of the liver and kidney, which have undergone intense fatty degeneration (Fig. 16, *b*, *c*, *d*); these colostrum corpuscles generally diminish in number very rapidly after parturition, although a few may continue to appear for months in the milk, without vitiating its nutritious or wholesome character. In some diseases of nursing women, such as rheumatism and the exanthemata, they continue to be found in great abundance, and appear to produce an irritating effect upon the alimentary canal of the infant: thus, for example, Dr. Hughes Bennett relates a case (Clinical Lectures on Medicine, New York reprint, 1860, p. 60) in which he was "called to see an infant a month old, which was in a state of considerable emaciation, with constant diarrhœa. The mother, however, maintained that her milk was abundant, and that it was taken in sufficient quantity. On being examined with a microscope, it was found to contain numerous compound granular bodies, and comparatively few milk globules. In short, it presented in an exaggerated degree all the characters of colostrum, and this thirty days after delivery. It was evident then that the *quality* of the milk was in fault, an opinion which was confirmed by the recovery of the infant when a healthy nurse was procured." The existence of colostrum corpuscles in the milk may occasionally be valuable in a medico-legal point of view, as affording a strong presumption of recent delivery, which in a doubtful case might be almost converted into certainty should they be found to disappear with the rapidity common in the

FIG. 16.



HUMAN MILK. × 200 Diameters. (After Kölliker.)

a. Oil globules. *b*, *c*, *d*. Colostrum corpuscles.

puerperal state. The appearance in the milk of red blood corpuscles, p. 175 (possibly from excoriation of the nipple), would be of course significant of hemorrhage; while the presence of Leucocytes (p. 95) in abundance, especially if associated with red blood globules, indicates severe irritation or inflammation of the mammary gland.

I was recently consulted in regard to the somewhat remarkable case of a Primipara, who, after an attack of puerperal mastitis, was alarmed at finding discharged from the nipple numerous branched cylinders or "strings" from two to five inches long and one-sixteenth to three-sixteenths of an inch in diameter, which were pronounced by her physician, a provincial practitioner, milk-tubes which had ulcerated out of the gland. Microscopical examination with a power of 200, however, showed that they were composed of an obscurely fibrillated substance, in which were *occasionally* and *irregularly* imbedded mucous corpuscles, and epithelial cells from the lacteal ducts, thus, of course, disproving the hypothesis of ulceration. It has occurred to me that these fibrinous casts, not very uncommon in the large intestine (see Chap. XII.) and also seen in the bronchial tubes (*vide* paper by Stephen Rogers, M.D., *Trans. N. Y. State Med. Soc.*, 1866, p. 41), are simply the result of an effusion of plastic lymph which has been so intimately associated, molecule by molecule, as it was poured out, with mucus, that it has thereby been prevented from attaching itself to the parts from which it exudes, and that this admixture in its nascent state with mucus is the true reason why fibrin effused upon a mucous surface does not present the phenomena seen in the ordinary adhesive inflammations of serous membranes.

Since investigating the above case, I have been informed by a country doctor that it is not unusual to draw out such long fibrinous strings from the teats of cows whose udders have been inflamed, and that the animals generally recover without permanent injury.

CHAPTER IX.

EXAMINATION OF THE BLOOD.

Since the clinical significance of pathological alterations in the circulating fluid can be justly appreciated only by those who are familiar with its physiological characters, I shall endeavor to detail, with a minuteness somewhat proportionate to the great importance of the subject, the characteristics of healthy blood, before attempting to point out the changes which it undergoes in disease.

As remarked by Prof. Virchow, we may consider the blood as a tissue consisting of cells, with a liquid intercellular substance, the former being made up of the red and white corpuscles, the latter of the blood plasma, or liquor sanguinis, an aqueous solution of albumen, fibrin, chloride of sodium, chloride of potassium, and other saline constituents, having a specific gravity of about 1028. Besides these, which are dissolved in the normal serum, we find mentioned by the editors of the Micrographic Dictionary, as unusual ingredients of blood—1st. Cells inclosing colored blood corpuscles, found in the blood of the spleen, liver, etc. 2d. Granule cells, either colorless or containing granules of pigment (?). 3d. Peculiar concentric bodies, three or four times as large as the colored corpuscles of the blood, resembling those found in the thymus gland. 4th. An unusually large number of colorless corpuscles. 5th. Pus corpuscles(?). 6th. Caudate cells, occasionally containing pigment. 7th. Crystals of hæmatoidine, at times within the colored corpuscles, at others free. 8th.

Two distinct kinds of a white, extremely fine, molecular substance; one consisting of fat, the molecular base of the chyle, the other a very finely divided albuminous substance.

The form of the RED CORPUSCLES of the blood varies extremely in different classes of animals, being generally in the mammalia circular, flattened disks, the sides of which are so excavated as to make them resemble double-concave lenses with rounded margins, commonly called the "water-cracker shape," while in birds, fishes, and reptiles they are usually elliptical, nucleated, and convex upon their flattened surfaces. The dimensions are also subject to great diversity, those of the Menobranchus or Proteus being about $\frac{1}{450}$ of an inch long by $\frac{1}{650}$ of an inch wide, while those of the musk-deer are said to measure only $\frac{1}{12325}$ of an inch across. The average diameter of the human red blood disks (Fig. 17) is variously stated at from $\frac{1}{3200}$ to $\frac{1}{3500}$ of an inch; according to my own experiments, the mean diameter of ten corpuscles, measured when magnified 1800 times, was $\frac{1}{3346}$ of an inch. As has been previously stated (p. 121), they undergo almost instantaneous alterations in shape and size on being immersed in liquids which are rarer or denser than the liquor sanguinis. The structure of the red blood corpuscles has long been a mooted question in histology, the older doctrine of Schwann, who thought that they were membranous sacs filled with colored fluid, being now denied by Flint, of New York, Beale, of London, and Robin, of Paris, who maintain that they are homogeneous, and composed of a soft jelly-like material; while recent German authorities, as, for example, Stricker and Brücke, assert that they comprise a colorless, porous substance, denominated Oikoid, in whose interstices resides a colored living organism, which they call the Zooid. From my own experiments, however, upon the blood of the Menobranchus,

as well as upon that of man, detailed in a paper read before the Section on Physiology of the American Medical Association at its Annual meeting for the year 1870, held at Washington, D.C. (*vide Transactions*), I conclude that the older theory in regard to the structure of the red corpuscles of the blood, which teaches that they are minute membranous bags filled with a colored fluid, explains the various phenomena they exhibit more satisfactorily than does any other hypothesis which has hitherto been advanced, and this view I sustained by some remarkable specimens of dried blood corpuscles of the Menobranchus, each containing one or more *crystals*, composed of the colored cell contents, *upon whose points was propped out the colorless cell-wall.*

A remarkable peculiarity of the human red blood globules is their tendency to arrange themselves into rows with their flat surfaces in contact, like piles or *rouleaux* of coin (see Fig. 17), a disposition which Robin asserts is caused by the exudation from each corpuscle, as the blood cools, of a glutinous substance (Fibrillogen) which causes them to adhere.

Much difference of opinion exists as to the mode of origin of the red blood corpuscles. Hewson supposed that they were formed in the spleen; Bennett, that they resulted from development of the nuclei found in the white blood globules; Flint considers that they arise by a true genesis in the sanguineous blastema; while other authorities have attributed their origin to the lymphatic glands.

The WHITE CORPUSCLES of the blood, as seen in ordinary serum, are globular in shape, grayish in color, and decidedly larger than the red disks, measuring about $\frac{1}{2500}$ of an inch in diameter. On diluting the liquor sanguinis with pure water the Leucocytes gradually swell up, one, two, or three nuclei, rounded or oval in form, and about $\frac{1}{6000}$ of an inch in diameter, come into view, if they are not previously

visible, *as sometimes happens*, and the cavity of the corpuscle between these nuclei and the cell-wall is generally found to contain a number of very actively moving particles, the whole putting on, in fact, the *salivary corpuscular* form of the Leucocyte (Fig. 10). If the serum is still further diluted, strong evidence of a cell-wall is obtained, as I describe in my paper On the Identity of the White Corpuscles of the Blood with the Salivary Pus and Mucous Corpuscles (Pennsylvania Hospital Reports, 1869, p. 252); for the globules continue to expand, and on reaching the diameter of about $\frac{1}{1400}$ of an inch the specimen then observed was seen "to *burst* suddenly, discharging a portion of its contents, whose outbreak resembled that of a swarm of bees from a hive, and some particles of which, actively revolving as they went, swam off to the confines of the field." When acted upon by acetic acid, the white corpuscles of the blood swell up still more rapidly than when water is employed, and the nuclei are rendered very distinct. Indeed, these nuclei are supposed by Flint, Beale, and others to be merely masses of albumen coagulated by the reagent; but, as I have often been able to recognize them in white blood corpuscles moving about in normal serum, I cannot consider this view correct.

One of the most remarkable properties of the white blood globules is their power of amœboid motion (see Fig. 15), a movement so named because it precisely resembles that of the Amœba, a genus of Infusoria, which are described as follows in the Micrographic Dictionary: "*Characters* (of the family). Animals composed of a glutinous substance, without integument or internal structure, constantly changing form by the protrusion or retraction of parts of the body, whence result variable expansions; movements slow. These curious organisms apparently

constitute the simplest forms of organic beings, for they consist of a single kind of matter, a simple mass of sarcode. When first placed upon a slide, they represent minute, rounded, semi-transparent masses; but soon one or more rounded or pointed lobes or transparent expansions are seen to shoot out from the margin. These move almost imperceptibly along the slide, and, becoming fixed to it, slowly draw the mass to the fixed point. They are usually found to contain within them other Infusoria, Diatomaceæ, Desmideaceæ, or other minute Algæ serving as food." According to Dujardin, the genus Amœba comprises fourteen species, "but the characters cannot be depended upon. They are found in almost all infusions which have not become putrid, also in the slimy *débris* covering bodies immersed in fresh or salt water. Their size varies from $\frac{1}{70}$ to $\frac{1}{2800}$ of an inch." From this description it will be seen that the Amœbæ (corresponding to Prof. Huxley's protoplasm or physical basis of life) represent vitality in so *undeveloped* a form that each portion of the organized globule can successively constitute itself, or at least be constituted, a substitute or make-shift for an arm, a leg, a mouth, a stomach, or an anus, without the existence of any real differentiation into those various organs. I have been thus minute in describing these Infusoria on account of the curious resemblance they bear to the white blood corpuscles, which latter have acquired so much importance through the researches of Cohnheim and the speculations of Huxley.

The relative number of the white corpuscles of the blood varies under different circumstances. Thus, according to Welker (Handbuch der Lehre von den Geweben, von S. Stricker, II. Lieferung, Leipzig, 1869, S. 301), "we find one white corpuscle on an average to 335 red ones; while Moleschott states the proportion as 1 to 357.

"The latter author asserts that boys have 1 colorless to

226 colored blood corpuscles; men, 1 to 346; old men, 1 to 381; girls, 1 to 389; girls while menstruating, 1 to 247; the same during the interval, 1 to 405; pregnant females, 1 to 281.

"Hirt found in the early morning, while still fasting, 1 white blood corpuscle to 716 red ones; half an hour after breakfast the proportion was 1 to 347; two or three hours later, 1 to 1514; ten minutes after dinner, 1 to 1592; half an hour after dinner, 1 to 429; two or three hours after dinner, 1 to 1481; half an hour after supper, 1 to 544; two or three hours after supper, 1 to 1227." According to the same author, the proportion in the splenic vein is 1 to 60; in the splenic artery, 1 to 2260; in the hepatic vein, 1 to 170; in the portal vein, 1 to 740.

According to Welker (Carpenter's Human Physiology, edited by Prof. F. Gurney Smith, Phila., 1860, p. 176), a cubic centimetre of human blood contains 4,600,000 red corpuscles, so that, estimating the cubic centimetre as equal to ·06 of a cubic inch, a cubic inch as weighing (the specific gravity of blood being 1060, and the weight of a cubic inch of water 252·5 grains) 267·4 grains, and the body of a man weighing 140 pounds as being composed of one-eighth ($17\frac{1}{2}$ pounds) of blood, we find the total average number of red blood disks is 35,090,335,032, and of white globules, allowing, as above, 1 to 335 red corpuscles, is 104,747,262.

The structure of the white blood corpuscles has long been one of the *questiones vexatæ* of microscopy, some authorities considering them as made up of organized granules which develop in the blood plasma and become agglutinated together; while others, as Dr. Beale, look upon them in their normal state as masses of structureless living germinal matter (the kind of material which is alone concerned in the production of everything that lives, and always derived from matter which existed before it), the

"granular matter" detected in them and supposed to enter into the formation of their substance being in fact only the *dêbris* resulting from change after death.

One of the most recent writers upon the subject, Prof. James Tyson, in his admirable résumé (The Cell Doctrine, Philadelphia, 1870, p. 108), asserts that an opinion which deems these granules "are particles of formed material or extraneous matter suspended in the formless substance, just as granular matter from without becomes entangled in the formless matter of the amœbæ, * * * would be incompatible both with the behavior of growing germinal matter, and the reaction by which it is known; for we note, on the one hand, that when germinal matter grows rapidly, these granules are the elements which increase most abundantly; and, again, that these are the portions most deeply stained by ammoniacal solutions of carmine or aqueous solutions of red aniline," and hence concludes, "We deem it incorrect, therefore, to describe germinal matter as in all instances structureless, and prefer, with Robin, to describe it as sometimes granular."

My own experiments and observations, not yet completed, however, incline me to the opinion that the white blood corpuscles, at least when fully developed, are membranous sacs (see p. 177), containing fluid in which float numerous molecular masses, and inclosing also one or more nuclei, generally of a rounded or oval form.

From the great increase in the number of white corpuscles in the blood of the splenic vein, it has been supposed that the spleen is the organ chiefly engaged in their production; but, as remarked by Dr. Flint, their persistence in animals after extirpation of the spleen shows that they are developed in other situations. The same distinguished physiologist observes, "The function of the Leucocytes is not understood; and the supposition that they break down and become nuclei for the develop-

ment of red corpuscles, which at one time obtained, is a pure hypothesis, and has no basis in fact."

According to Dr. E. Neumann, however (*Archives die Heilkunde*, 1869, p. 68), "In the bones, during the whole of existence, a continual transformation of lymph corpuscle-like cells into colored blood cells occurs," a conversion which he considers to take place in the vessels of the osseous medulla and to be favored by a decided obstruction of the current of blood. This process, he believes, is accomplished by a gradual formation of hæmato-crystalline within the cell-wall of the Leucocyte, and the progressive absorption of the nucleus (or nuclei), with simultaneous contraction of the corpuscle, to the size of the red disk. I have not, however, as yet seen any published observations corroborating the interesting results at which he has arrived.

In examining the blood of a patient microscopically, it is necessary to take great precautions against its admixture with any extraneous matter *after* it leaves the walls of its vessels. In ordinary cases I have found it sufficient to wash one finger thoroughly with soap and water, dry it with a new towel, puncture the ball by a quick stab, to the depth of an eighth of an inch, with a cataract- or ordinary sewing-needle, press out a small drop of blood, touch to it the middle of a carefully-cleaned slide (taking care to avoid bringing the surface of the latter in contact with any part of the bleeding finger), which is then to be quickly covered with thin glass and transferred to the stage of the microscope, where a power of 250 diameters will be found sufficient to determine the presence or absence of Leucocythæmia, although for some other investigations one of not less than 1000 diameters is requisite. From my experiments (*Am. Jour. of Med. Sciences*, July, 1868) I am convinced that there is little danger of contamination, with ordinary care, from slides or covers, or from the

momentary exposure to the atmosphere, my results after soaking the glasses in strong hydrochloric acid and then burning it off in the flame of a spirit-lamp being almost precisely similar to those obtained where no such precautions were used.

The method we have frequently employed in the Pennsylvania Hospital, being the one introduced there by Dr. J. Forsyth Meigs, Senior Attending Physician to that Institution, as described in the Reports for 1868, is as follows: "The integument (usually under the edge of the scapula) was cleansed with sponge and towel, and held upon the stretch between two fingers. It was then pierced with the fleam of a spring lancet, and (the wound not being allowed to close, but its lips held altogether apart) a little blood was carefully taken from the bottom of the wedge-shaped opening. Admixture with any elements of the epiderm was thus entirely prevented, and the contents of the small vessels of the true skin and subcutaneous tissue obtained pure." Prof. J. H. Salisbury, of Cleveland, Ohio, who has probably examined with the microscope more specimens of blood than any other ten physicians in this country (see Microscopic Examinations of Blood, New York, 1868), was accustomed to make a small incision in the external surface of the skin upon the forearm, near the wrist, and, after pressing out a drop of blood, to quickly transfer it to a slide, upon the point of the lancet.

In the investigation of a specimen of blood obtained in either of these three methods, one of the most important objects is perhaps the detection or exclusion of Leucocythæmia, an affection defined by Dr. Aitken to be "a disease *sui generis*, in which the number of white corpuscles in the blood is greatly increased, with a simultaneous diminution of the red. This state is brought about by chronic exhausting diseases, exposure to cold and wet, or serious acute affections, such as typhus fever, pneumonia, puerperal

fever, affections of the lymphatic glands or of the spleen, and is attended sometimes by cough or diarrhœa, epistaxis, hemorrhagic effusions, furunculous or pustulous eruptions." For this purpose a definite standard must be obtained, and this is perhaps best accomplished by testing a drop of blood from some person in robust health, and counting the average number of white globules in five or ten fields, chosen in portions where the film is so thin that but a single layer of red disks exists between the slide and cover. It is obvious that, strata of blood similar in thickness being selected, and the same lenses being employed, we can, by simply enumerating the average number of white corpuscles in view at any one time, obtain a very good estimate of the ratio the Leucocytes of any particular specimen bear to those of normal blood. Of course, slight variation in this number, unless very persistent, cannot be esteemed of importance, since, as shown by the table quoted on p. 176 the white cells vary within certain limits, according to the time after taking food, or rather the stage of digestion, and perhaps other circumstances. But should we find ten times the standard number of white corpuscles as the average visible in a field of view, we may feel confident of the existence of Leucocythæmia, although the affection would probably be in an incipient stage, since advanced cases present the white globules sometimes equaling the red ones in abundance, and thus several hundred times exceeding their ordinary sum total.

The first discovery of Leucocythæmia as a distinct affection seems to be due to Drs. Craige and Bennett, of Edinburgh, in 1845. They, however, looked upon it as a suppuration of the blood; and the true pathology of the disease was first, and it appears quite independently, recognized by Prof. Virchow, of Berlin, in the same year.

As remarked by Dr. Aitken, the increase of the colorless corpuscles of the blood, which is the prominent character

of the disease, does not seem in any case to have existed or occurred by itself. Other morbid states precede, co-exist with, or succeed the augmentation of the colorless corpuscles. Of these complications, enlargement of the spleen is the most common, occurring in nearly eighty per cent.; next that of the liver, found in over sixty per cent.; in almost one-half the cases affections of the lymphatic glands generally predominate; and when this disposition is associated with a tendency to the excessive formation of adenoid tissue, we have the lymphatic form of Leucocythæmia described by Virchow in 1847 as Lymphæmia.

According to the elaborate researches of MM. Ollivier and Ranvier (*Archives de Physiologie*, tome deuxième, Paris, 1869, p. 411), this adenoid tissue appears to be composed of aggregated white blood corpuscles contained in a network of enormously dilated capillaries; and to the presence of such distended blood-vessels these gentlemen attribute the various symptoms, such as cephalalgia, dyspnœa, and even orthopnœa, and occasionally the hæmatemesis and melæna, occurring in this affection. According to Dr. Aitken, the causes which bring about Leucocythæmia are entirely unknown; but it seems several times to have suggested itself to Virchow that acute inflammatory processes may lay the foundation of the morbid state, and in an interesting review of his writings, in the *British and Foreign Medico-Chirurgical Review* for July, 1857, there is related a case of the lymphatic form of the disease, whose origin obviously dates from inflammatory swellings of the lymphatic glands, after exposure to cold and wet. Dr. Aitken saw a similar case in Guy's Hospital, in July, 1863; it occurred to a man after exposure to cold and wet on Epsom Downs at the time of the races there. Dr. Bennett states, with regard to treatment, nothing that he has yet tried has appeared to be of the slightest service in well-marked cases of Leucocythæmia associated

with distinct glandular enlargements. Iron, quinine, chloride of potassium, hydriodate of potash, and a variety of medicines, given internally, with tincture of iodine applied externally, have been of no avail. The chief indications in advanced cases, however, will be found to be furnished by accidental complications, the most common of which are diarrhœa and epistaxis, which require astringents, combined with tonics, nutrients, and stimulants, to support the vital powers. Aitken advises the use of the nitro-muriatic bath, and suggests that if it is possible to discover the glandular or splenic affection early, before the alteration of the blood has made much progress, it is probable that the disease may be averted.

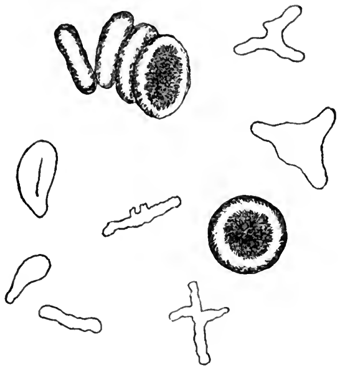
Occasionally, establishing the absence of Leucocythæmia may give important aid in the diagnosis of obscure abdominal tumors, as in the following case reported in the *American Journal of Medical Sciences* for July, 1865. "The patient, a widow lady, aged fifty six, consulted me on account of severe pain in the hypogastric and left lumbar region, where, on examination, I found a firm, rounded mass, which was nodulated in the left iliac fossa. Under proper treatment the pain was soon relieved, and during the next few weeks she was seen and examined by several physicians in consultation, one of whom felt satisfied that it was an inflammation of the peritoneum investing the uterus and ovaries; another, who has practiced in this county for nearly fifty years, insisted that it was an enlarged spleen, and nothing else; while a third, who did not see her, after a minute inquiry into all the symptoms, decided it was a uterine growth. It appeared, however, that the size and painless course of the tumor rendered pelvic cellulitis improbable; while the normal length of the cavity of the womb, as ascertained by Simpson's Uterine sound and the lateral origin of the tumor, negatived the hypothesis of uterine disease. In regard to

enlargement of the spleen, although she had suffered from intermittent, yet, by careful percussion, I was able to mark out that organ in its normal position, and the microscope afforded additional evidence, by proving the absence of Leucocythæmia, the relative number of the white and red corpuscles being found, on examination, to retain its natural proportion. By these considerations, and in view of the rapid growth of the tumor, its bossilated character, and the patient's loss of flesh and strength, I was led to the diagnosis of ovarian dropsy, probably originating in carcinomatous disease,"—an opinion which was fully confirmed at the autopsy held a few months later, when the spleen was discovered to be perfectly normal in size, shape, and position.

Variations in the number of the red blood corpuscles, which may be either increased or diminished, constituting Polycythæmia and Oligocythæmia of Julius Vogel, frequently occur, and may be either absolute or relative: in the former case the corpuscles are uniformly increased or diminished throughout the body generally; in the latter this depends upon the amount of water, which, being less or more, alters the proportion of the corpuscles to the other constituents of the blood. From some observations of my own upon a female patient in the Pennsylvania Hospital, the subject of profound anæmia, it would appear that this apparent diminution in the absolute number of the red disks may sometimes, at least, be the result simply of a loss of hæmato-crystalline, while the cell-walls (see p. 176), shrunken and distorted, still remain floating in the liquor sanguinis, and recognizable when the blood is examined with a lens of sufficiently high power. Such, at any rate, seemed to be the case in the two examinations I had an opportunity of making, in this individual (Fig. 17); but I was unfortunately prevented, by her abrupt departure out of the hospital, from observing the further progress of her complaint.

According to Dr. Beale, "in some cases of cholera, several cells much larger than the white corpuscle have

FIG. 17.



RED BLOOD CORPUSCLES AND SHRUNKEN CELL-WALLS, FROM A CASE OF PROFOUND ANÆMIA. × 1200 Diameters.

been found in the blood, although it is probable that their nature is closely allied to these. In a case which I had an opportunity of examining some years ago, many of these large cells contained oil globules collected together in one part, leaving the remainder of the cell perfectly clear and transparent as if the endosmosis of fluid had occurred. I have also seen very large white blood corpuscles in cases of pyæmia."

As stated by Prof. F. G. Smith (Carpenter on the Microscope, Philadelphia edition, 1860), "where the blood is thickened from an excess of fibrine, the colored corpuscles become caudate or flask-like in shape, and aggregate themselves into irregular masses instead of in the form of rouleaux." Such adhesion of the corpuscles is said to be frequently met with in cases of cholera. But a very interesting experiment, tried, with true devotion to

the cause of science, by Dr. Beale, renders it extremely probable that this peculiarity has no special relation to the disease, but is due simply to the blood being deprived of much of its water. Dr. Beale says: "One day I took some Epsom salts, which produced three very copious liquid stools. I examined a drop of blood from the finger, and found the corpuscles adhering exactly as represented in the figure (rendering them elongated and caudate). I then took three tumblers of warm water, and, in less than an hour after the first observation was made, the blood corpuscles exhibited their ordinary characters, forming the piles of disks, but not exhibiting the peculiar tendency to adhesion, above referred to."

So much has been said in almost all of the medical journals throughout the civilized world in regard to the alleged discovery claimed to have been made by Prof. G. B. Halford, of Melbourne, Australia, in regard to certain "peculiar cells" found by him in the blood of animals poisoned by the bites of venomous serpents, and supposed to occur in cases of cholera and other rapidly fatal diseases, that it seems worth while to quote the results of some observations made in conjunction with Dr. S. Weir Mitchell, of this city, on animals poisoned with rattlesnake-venom, and reported in the *Am. Jour. of Med. Sci.* for April, 1870, as follows, viz.: "Proceeding now to group together the results of these experiments, it will be seen that in the examples of a rabbit, dog, and goat so poisoned by rattlesnake-venom as to survive its insertion from one to six hours only, whose hearts were allowed to remain unopened from twelve to twenty-four hours after death, the temperature varying from 75° to 90° Fahrenheit, the blood, when removed from the cardiac cavities in such a way as to avoid all contamination, and carefully examined with a high power (one twenty-fifth inch objective), exhibited cells corresponding perfectly to those described by

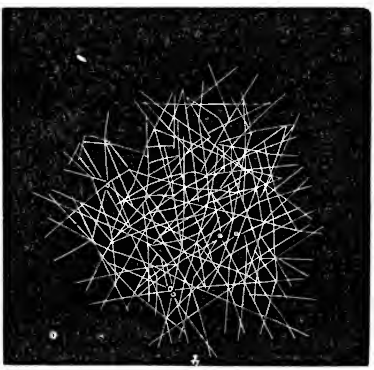
Prof. Halford. Yet these so-called 'peculiar' cells were always mingled not only with white blood corpuscles in their ordinary 'pearly and opaque' condition, but also with those in various stages of enlargement, an alteration such as may be at any time produced in the white globules of normal blood simply by diluting the liquor sanguinis with water. And, further, that in the case of the goat, when a majority of the 'peculiar cells' presented the unusual character of being multi-nucleated, the white blood globules, if distended by water, exhibited the same peculiarity. We may therefore, I think, fairly conclude that the abnormal corpuscles in these particular instances were in reality only white blood globules which had undergone a change similar to that caused by reducing the specific gravity of the blood, and so establish a strong presumption (whose correctness Prof. Halford can alone decide) that the 'peculiar cells' described by him as resulting from the poison of snake-bites are precisely analogous in their character."

A third form of abnormal variation in the appearance of the blood under the microscope is a preponderance of the molecular substance (the globulin of Donné), which is naturally abundant after full meals of fatty food, and said also to occur in abundance during long fasting, pregnancy, the use of spirituous liquors, and in the course of Bright's disease; constituting the so-called Galactæmia or Lipæmia. When coagulation takes place in blood drawn by venesection from patients so affected, these molecules are found chiefly in the liquor sanguinis, to which they impart a milky or turbid appearance. According to Von Düben, their presence in the blood indicates imperfect hæmatosis and assimilation, and perhaps inefficient purification of the blood by the secretory and excretory organs.

Modifications in the quantity and probably the constitution of the FIBRINE of the blood (Fig. 18) may be readily

recognized under a good objective, as appears to have been first demonstrated, in this country at least, by Prof. Salisbury, of Cleveland, Ohio (see Microscopic Examinations of Blood, New York, 1868, p. 15). He states that "In rheumatic conditions the filaments of the fibrine network of the blood are in a tonic state of contraction; this increases the size of the filaments, making them more plainly visible, and decreases the size of the meshes, so that the blood is in the premonitory stage of clotting; the meshes being so small that they interfere with the free passage of the blood-elements, they holding partially in their meshes the colored and colorless corpuscles. This makes the blood have a ropy, half-clotted appearance between the slides. In a few minutes after rheumatic blood is placed between the slides, the colorless and colored corpuscles arrange themselves in ropy rows and masses, leaving large, irregular, clear spaces,

FIG. 18.



APPEARANCE AND ARRANGEMENT OF THE FIBRINE FILAMENTS OF BLOOD IN HEALTH. (After Salisbury.) × 200 Diameters.

in which may be distinctly traced the mesh-work of fibrine filaments. Frequently, for months before the patient has any idea that he is rheumatic, or in danger of being at any

moment taken suddenly down with rheumatism, this condition may be positively diagnosticated by the appearance and condition of the blood." The same author further remarks (and this statement I have verified by repeated observations) that the network of fibrine is much more distinct in specimens of blood drawn from patients affected with pulmonary tuberculosis, pneumonia, and probably other inflammatory diseases. It has occurred to me that this method of investigating the blood for the detection of fibrine filaments might sometimes be very useful in recognizing the hemorrhagic diathesis, and so determining the propriety or otherwise of resorting to any surgical operation, however trivial (the simple extraction of a tooth having proved fatal), in patients who are the subjects of this remarkable idiosyncrasy. Niemeyer (Text-Book of Practical Medicine, Humphrey's and Hackley's translation, New York, 1869, vol. ii. p. 736) observes that Hæmophilia or Hæmorrhaphilia (the malady above referred to) is distinguished by an unusual obstinacy of traumatic hemorrhage, or a tendency to spontaneous bleedings; also, that no anatomical abnormity can be discovered; and the complaint is generally hereditary, although it often does not show itself until the sixth or eighth year of life. In its treatment he recommends Glauber's salts, in cathartic doses, and asserts that from two to five grains of Secale cornutum, administered every half-hour, have been of much service.

Dr. Hughes Bennett narrates the case of a woman who died of cholera, exhibiting a remarkable alteration in the blood: "It consisted in the colored corpuscles being paler than usual and the colorless ones normal; but mingled with these were others, varying in shape and size. They were generally circular, but some were oval and a few caudate; they had a well-defined external smooth border, having one or two bright refracting granules, generally situated in the external membrane and occasionally

projecting from it. When seen edgeways, they were flattened, and existed in the proportion of one to seven of the colored corpuscles. Their long diameter varied from $\frac{1}{1200}$ to the $\frac{1}{2000}$ of an inch, and their transverse diameter from the $\frac{1}{2000}$ to $\frac{1}{4000}$ of an inch. The addition of acetic acid caused them to swell out, dissolved their external wall, and liberated the granules; aqua potassæ rendered the whole structure paler; and a solution of muriate of soda rėndered them more distinct and of smaller size."

In certain internal hemorrhages, according to the same author, the red corpuscles break down after remaining (without the effused blood being absorbed) for a considerable length of time, or become partly dissolved, when the external envelope is seen to be very transparent, apparently containing one or several granules. The same change is observed in blood extravasated beneath the skin in scurvy or purpura, and, as I have recently observed, in retained fluid of cases of Suppressio Mensium. (See Chap. XII.)

Among the foreign elements in the blood, epithelial cells from the mucous membrane lining the blood-vessels have been found, and Joseph Meyer is said to have seen them in the circulating blood of a frog, while Virchow reports observing oblong epithelial cells, containing fatty and pigment molecules, in bodies of patients who had died of intermittent fever and cancer of the womb; Mackall has seen pigment cells, and Frerichs asserts that pigment granules, in flakes and scales or contained in cells of very irregular rounded or sharp outlines, are common in the blood of malarial disease. Donders and Vogel suggest the possibility of epithelial cells, aggregated together in the blood's stream, becoming impacted in the smaller arterial twigs, where they give rise to thrombosis and the formation of abscesses of the blood-vessels, so frequent in puerperal and pyæmic fever.

The occasional presence of cancer cells circulating in

the blood has been maintained by such high authorities as Virchow, Bennett, Paget, and Quekett; but, if they do exist, it is so rarely that the fact is probably devoid of practical importance, and it seems possible that epithelium from the mucous coat of the arterioles may have been mistaken for the cells of carcinoma.

Von Düben states that in the blood of certain quadrupeds Entozoa are constant elements; as, for example, Filariæ in dogs, Strongylus armatus in the horse, etc.; and the same has been asserted of human blood, Duval professing to have seen Fasciolæ in the portal vein; Brauell states positively that he has observed Vibriones in the blood of glandered horses, and more recently M. Davaine, of Paris, has announced the discovery of Bacteria in the blood of both man and the inferior animals affected with carbuncle and malignant pustule, although my own researches tend to show that such Infusoria exist, at least in small numbers and a rudimentary form, in the blood of persons enjoying ordinary health (see my paper entitled "Experiments showing the Occurrence of Vegetable Organisms in Human Blood," *American Journal of Medical Sciences*, July, 1868). The development of the Bilharzia hæmatobia, and perhaps the B. capensis, in the portal veins of patients suffering from an epidemic dysentery and hæmaturia very common in Egypt, at the Cape of Good Hope, and at Natal, is now so well authenticated that it seems to be beyond dispute. According to Professors Bilharz and Griesinger, the ova of this parasite have been met with in the parenchyma of the liver, the membranes of the small intestines, but especially in the submucous cellular tissue of the bladder, the ureters, seminal vesicles, sigmoid flexure, and rectum. Professor W. Griesinger explains the deposits of the ova in the uro-genital organs, particularly in the polypous vegetations of their mucous membrane, sometimes incrusted with urinary deposits, by

supposing that "the male, bearing an impregnated female in his canalis gynocopherus, forces itself against the current of the blood into the smaller branches of the venous plexus; with the aid of its locomotory apparatus, consisting of sunken disks and minute bristles, it works its way and deposits its ova, which are united into lumps by a gelatinous substance, within the capillaries. Passive hyperæmia, stasis, and effusion of plastic lymph ensue, the vessels burst, and thus the ova are placed into cellular tissue, from which they pass to the surface of the mucous membrane lining the bladder or are discharged with the urine."

Professor Lionel Beale is led to believe, through his researches upon the cattle-plague, that the presence of numerous masses of germinal matter (contagium) introduced from without into diseased blood and of products resulting from their death and decay may give rise by their multiplication in the capillaries to circumscribed local congestions, which result in the production of various peculiar eruptions and rashes. "In many cases the congestion ends in complete stagnation followed by suppuration (boil, carbuncle, pustule) and the death, destruction, and removal of the portion of tissue affected; or it is followed by the escape from the blood and lymphatics of serum and small particles of germinal matter, which multiply for a time in the substance of the cuticle, the superficial portion of which is elevated (vesicle, bulla), the fluid and corpuscles drying up and forming with the altered cuticle and secretion of the sebaceous glands a *scab* or *crust;* or a raw, moist surface which does not readily heal, known as an *ulcer*, is formed beneath the detached layer of cuticle." Dr. Beale further states that, although difficult, he has "succeeded, by squeezing the blood *from* the capillaries toward an opening in a vein, in obtaining clots with numerous particles of germinal matter."

Dr. Sansom, whose excellent monograph (Chloroform, its Actions and Administrations) has rendered him so well known in this country as well as in his own, appears to have been led by some of his experiments to suspect that chloroform during its inhalation had a specifically destructive effect upon the red blood corpuscles; but Dr. J. H. McQuillen, Professor of Physiology in the Philadelphia Dental College, has shown by an elaborate series of observations upon the blood of human beings and various inferior animals before, during, and subsequent to the existence of chloroform narcotization, that no visible change in the aspect of the red disks takes place. (*Vide Dental Cosmos*, March, 1869.)

It would be manifestly improper, in such a work as the present, to enter upon the discussion of the origin in the blood of zymotic diseases from fungous growths, especially as the weight of authority is still so ponderous against its recognition. Suffice it to say that, on the one hand, among others Salisbury, of Cleveland, Ohio, maintains that intermittent fever, enteric fever, and small-pox are produced by fungi, which he has named Gemiasma viridis, etc., Byolysis typhoides, and Ios variolosa respectively; Hallier of Jena advances the theory that cholera is caused by a peculiar development of his so-called micrococcus, and, in conjunction with Dr. Stiles (Third Annual Report of the Metropolitan Board of Health of the State of New York, p. 311 *et seq.*), attributes the Texas cattle-disease to the Coniothecium Stilesianum, and Davaine of Paris asserts that carbuncle and malignant pustule have their origin in the growth of Bacteria and Bacterida in the blood; while, on the other hand, Prof. H. C. Wood, Jr., of this city, in an able article,* plethoric with negative evidence, denies that there are any known facts establishing the doctrine of animate contagion,

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* American Journal of Medical Sciences, Oct. 1868, p. 352.

and Drs. Billings and Curtis, in their report on the asserted causation of some cattle-diseases by fungi,* as a result of their elaborate and ingenious experiments, declare that they have failed to establish the presence of any peculiar or special cryptogamic germs in the blood. Nevertheless, when we remember that the great law of Nature's economy appears to be a never-ending struggle (*wherever possible*) of each organism and every class of organisms *for its own existence against every other form of life*, and recall the fact that in the vegetable world such devastating plagues originate in the growth of the cryptogams which produce the vine-blight, the potato-rot, and rust and smut in the cereals, it seems highly probable that some (perhaps the same) minute organic entities, contemptible in their immeasurable minuteness but terrible in their almost infinite number, do possess like destructive powers over the animal kingdom; and that their discovery, when made, if it be not already accomplished, will ultimately enable us, far better than ever before, to struggle with disease. At present, however, *proofs* of such a theory seem to extend no further than the facts—first, that Bacteria develop in blood which has been drawn from the vessels, absolutely without exposure to the air, as shown by the observations of Frau Lüders, of Kiel, admitted by Prof. H. C. Wood, Jr., and confirmed by Drs. Billings and Curtis; and, second, that Bacteria taken into the stomach may pass from thence into the blood, as occurred in experiments upon myself, detailed before the Central New York Medical Association at Rochester, June, 1868, published in the *American Journal of Medical Sciences* for July of the same year, and corroborated by Dr. W. Neftel in the *New York Medical Record* of July 15, 1868.

Beside and beyond all this, however, should the preg-

* American Journal of Medical Sciences, Oct. 1869, p. 526.

nant doctrine of Heterogeny, as advanced and ably maintained by Pouchet, Pennetier, Mantegazza, and their disciples, be at some future time fully demonstrated, it must largely modify any view of the parasitic origin of diseases.*

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* Whilst these pages are passing through the press, I find the Lancet of July 9, 1870, announces that Dr. H. Charlton Bastian, of London, has in preparation a work on Spontaneous Generation (portions of which he has already published), whose object is to demonstrate by elaborate series of experiments "that low forms of life become developed in organic fluids without the presence of air, absolutely *in vacuo*, and in fluids that have been previously raised to temperatures that have been universally admitted to be destructive to the vitality of all known germs; and not in organic fluids only, but in saline solutions, and in saline solutions containing no carbon, and in which that element has been replaced by silicon. Such results, when the experiments producing them have been properly repeated and tested by other observers, will go far to strike at the root of whole systems of thought that are at present cherished by large numbers of earnest people. And yet, as we have often had occasion to maintain, the doctrine of germs, and especially of the germinal origin of disease, almost requires the doctrine of spontaneous germination as its complement," etc.

CHAPTER X.

EXAMINATION OF SPUTUM IN PHTHISIS, ETC.

THE diagnostic importance of the sputa when subjected to microscopic investigation has long been admitted, but this value has been greatly increased by Dr. Fenwick's invention of a method by which the fragments of lung-tissue separated in the pulmonary ulcerations of phthisis and tuberculosis can be readily recognized. There is no doubt that we are in this way sometimes enabled to detect tubercular consumption during an early period of the attack, and at a time when the signs and symptoms, without its aid, are still inconclusive.

The microscopist who attempts to derive assistance from the examination of sputum, as ejected from the mouth, should first render himself familiar with the usual appearance of ordinary expectoration as it becomes mixed with the various normal and accidental contents of the oral cavity, which object can only be accomplished by careful and oft-repeated investigations of these matters obtained from healthy individuals. Besides the ingredients and impurities of saliva described in Chapter VIII. (page 164 *et seq.*), and comprising salivary corpuscles, epithelial cells from the buccal and lingual mucous membranes, filaments and spores of the Leptothrix buccalis and other fungi, articles of food, such as starch corpuscles, portions of striated muscle, fragments of cellulose and other vegetable tissues, etc., we may expect to find specimens of the great variety of substances constantly

floating in the atmosphere and inhaled with it into the lung, such as particles of hair, wool, dust, feathers, carbon, pollen-grains, etc., all of which render the examination of sputum one of the most difficult although one of the most instructive as a study to the microscopist that can be undertaken. When investigating the contents of sputum as expectorated, it is necessary to examine different specimens from various parts of the mass, especially those which to the naked eye or a hand magnifying glass appear to vary in constitution, as the minute fragments of some particular ingredient searched for may otherwise escape detection. It is recommended by Dr. Hughes Bennett, and some other authorities, that the sputa under consideration should be stirred up with a considerable bulk of water, in order that certain portions may be selected as objects of research; but Prof. Beale objects to this method, on the ground that the admixture of water necessarily causes a physical alteration of many of the cells and produces complete disintegration of others. Such inconvenience may, however, be entirely obviated by employing as a menstruum, instead of water, the weak syrup suggested on page 37 (but without carbolic acid), or the dilute glycerin; and this method will, I think, often be found the preferable one to pursue. Much difficulty is frequently experienced in separating small pieces of viscid sputum from a tenacious mass, and repeated efforts must often be made before this can be accomplished. Dr. Beale describes a peculiar pair of forceps, having their blades cup-shaped at the extremities, which he thinks partly overcome this obstacle; but, as a general rule, the ordinary forceps and scissors of the dissecting-case may be made to answer every purpose. A few drops of the syrup above mentioned should be added to the more opaque specimens, as placed upon the slide, the mass torn out with the mounted needles, so as to form a thin film, with ragged edges, when the glass

cover is applied, and pressed down with moderate firmness. On placing a slide so prepared upon the stage of the microscope, and examining with a power of 200 diameters, the more or less distinctly fibrillated mucin, which forms the bulk of expectorated material as ejected from the trachea of an individual whose pulmonary organs are healthy or nearly so, can generally be clearly seen, and imbedded in it may often be observed the so-called mucous corpuscles (Leucocytes, *vide* Chapter VIII.), exhibiting more or less active amœboid movements (Fig. 15).

The expectoration which forms one of the most prominent and distressing symptoms of hydrophobia consists of a dense, tenacious mucus, the Leucocytes of which appeared to me to have undergone a species of fatty degeneration, in a well-marked instance treated in the Pennsylvania Hospital during the summer of 1869, by Dr. J. Forsyth Meigs, Senior Attending Physician, who will probably publish a complete history of the case in an early number of the Philadelphia *Medical Times*.

If a specimen of sputum thus examined is found to contain a large number of Leucocytes, it affords a strong evidence that irritation of the mucous membrane lining the bronchia exists to such an extent as to cause a more or less serious impediment to the circulation of blood in the vascular network beneath the epithelial layer. And, again, should the expectorated matter be composed chiefly of Leucocytes, with a few red blood disks intermingled, we may conclude (unless some hemorrhage has occurred) that a true inflammation of the bronchial membrane has been set up, and has resulted in the muco-purulent secretion of bronchitis. According to Peacock, as quoted by Hughes Bennett, the sputum of acute pneumonia often contains fibrinous casts of the bronchial tubes, having imbedded in them pus and pyoid corpuscles; but my own observations, as a general rule, accord more closely with

those of Dr. Beale, who states that the rusty sputum, in its early stages, contains a number of large spherical collections of minute oil globules, exudation corpuscles, or granular cells, together with a vast number of minute granular corpuscles of a circular form, which are developed in the exudation poured out in the air-cells of the lung, with numerous blood globules, for the most part separated from each other, to the presence of which the peculiar color of the sputum is due. At a later stage, in bad cases, the quantity of blood increases, the mass is nearly fluid (constituting the diffluent prune-juice sputum), and contains an immense number of disintegrated cells, and much granular matter, with numerous altered and ragged red blood corpuscles.

In some investigations into the condition of pneumonic lung in the early stage of red hepatization, contributed for a paper by Dr. J. H. Packard in the *Am. Jour. of Med. Sciences* for January, 1870, I found that under a $\frac{1}{25}$ many air-cells could be seen, entirely filled with a mixture of Leucocytes and red blood corpuscles, in about equal proportions, with some epithelium, and but little of the fibrinous material described by Prof. Bennett; and it occurred to me that perhaps a higher magnifying power might resolve the masses he describes into similar ingredients, as maintained by Dr. J. M. Da Costa, of this city, in his able paper on the Minute Anatomy of Pneumonia, published in the *American Jour. of Med. Sci.* for October, 1855.

Dr. Walshe (Diseases of the Lungs, Philadelphia reprint, 1860, p. 279) asserts that this frequent replacement of pus cells by exudation corpuscles, announced by Dr. Da Costa as a novelty, has been mentioned yearly in his own lectures since 1847; but, of course, the doctrines in regard to the identity of all Leucocytes, taught in this

work, render a revision of all such observations necessary.

Microscopic examination of substances ejected from the mouth will often enable us to decide where the red blood disks contained in the sputum have been effused. For example, if the red disks have lost their color, have become thicker than normal, or bell-shaped (as imperfectly shown in Fig. 17), and are associated with Leucocytes having the *Salivary Corpuscular Form* (Fig. 10, also Chapter VIII.), we may presume that the hemorrhage has taken place within the oral cavity; or should the red globules be of normal shape and color, and accompanied by "mucous corpuscles" exhibiting, when examined upon a slide that is slightly warmed, the characteristic amœboid movements, it is probable they have been effused, if the hemorrhage is small, in some part of the fauces or trachea. Again, cases sometimes occur when there is doubt whether blood said to be vomited is not rather the result of hæmoptysis, and *vice versa*, a question which may occasionally be decided in favor of hæmatemesis by the discovery of a large quantity of starch granules, muscular fiber (see Fig. 14), or other articles of food. Lastly, from an example which occurred in the Pennsylvania Hospital several years since, while I was resident physician to that institution, I think we may sometimes diagnosticate pulmonary hemorrhage by the form of the clots expectorated. The case, which, although I unfortunately have no notes of it, is vividly impressed upon my memory, was as follows: A middle-aged colored man, by occupation a carter, was admitted as a recent accident, having fallen from his cart in front of the wheel, which passed over his body diagonally, crossing the lower part of the thorax on the right side, and the upper part of the abdomen on the left. When brought in, he was suffering from severe depression of the vital powers, whence he never reacted, but died in

about thirty-six hours, evidently from shock, and loss of blood, which, while his strength lasted, he expectorated freely. I examined a number of specimens of this sputum, and found that all showed numerous rounded coagula, varying from semi-oval to oval, in the latter case closely resembling in shape and size the pulmonary vesicles, of which they seemed to be *casts*. At the autopsy, the liver was found to be ruptured, the cavity of the peritoneum contained a large amount of blood, and the lower lobe of the right lung was bruised slightly, torn, and nearly filled up with dark, moderately firm clots; specimens of bloody mucus taken from the larger branches of the right bronchus showed coagula of similar shape and size to those found before death in the expectoration. I have long hoped to be able to corroborate this observation in other analogous cases; but, no opportunity having occurred, I now give it for what it is worth.

The detection of malingerers is one of the crowning triumphs of microscopic diagnosis, as in the following case related by Prof. Hughes Bennett, which teaches us how important is such examination, even where observation with the naked eye seems amply sufficient to determine the disease. Dr. Bennett states, "Some years ago I was summoned to see a dispensary patient laboring under bronchitis, who was spitting florid blood; and, examining the sputum with a microscope, I found that the colored blood corpuscles were those of a bird. On my telling her she had mixed a bird's blood with the expectoration, her astonishment was unbounded, and she confessed that she had done so for the purpose of imposition."

According to Von Düben, portions of tissue strongly resembling fragments of mucous membrane sometimes detach themselves and become mixed with the sputum ferruginosum of pneumonia. He states that they differ from casts of the bronchial tubes, above referred to, in

presenting none of the granules which occur in the latter, and in being more irregular and flattened in form; he also describes, as a quite constant ingredient of pneumonic sputa, red flakes, minutely granulated, of variable and indefinite shape, consisting apparently of hæmatine, and remarks that "in either bronchitis or pneumonia the physical signs are pretty reliable clinical guides; but in lobular and occult pneumonia the microscope is indispensable for early and correct diagnosis."

It is now nearly twenty years since it was first established by Schröder van der Kolk and Dr. Andrew Clark, that small fragments of elastic fiber from the walls of the pulmonary vesicles may sometimes be detected by the microscope in the expectoration of persons suffering from phthisis. Prof. Beale recommends that several specimens should be cut off from the sputum, any "little grayish masses" being particularly selected, treated with acetic acid, and carefully examined; but to Dr. Samuel Fenwick, Assistant Physician to the London Hospital, we owe the important suggestion of first liquefying the sputum by boiling it with caustic soda, in which process we disintegrate most of the cell-elements, which obscure the view under the microscope, and then, on allowing the fluid to stand undisturbed in a conical vessel, all the elastic tissue, upon which diagnosis mainly depends, sinks to the bottom, and may readily be detected by the examination of a very few slides, instead of requiring for its discovery the tedious research for hours which was formerly necessary.

So important is the subject of early diagnosis in that wide-spread and much-dreaded disease, consumption, that I propose to quote at some length the very valuable paper of Dr. Fenwick in the *London Lancet* for Dec. 5 and 12, 1868, illustrating and combining it with my own observation in the wards of the Pennsylvania Hospital.

In attempting to test the sputum of a supposed case of

phthisis by this method, I have found it advisable to direct the patient to expectorate for twenty-four hours into a clean porcelain cup, taking great care to avoid depositing anything but what he coughs up in the vessel, and to prevent any other person from spitting into it; also to chew no tobacco, and to rinse out the mouth thoroughly after eating, during that day. If only a smaller quantity of expectoration can be obtained, it is advisable to examine that ejected on getting up in the morning. About a fluid-ounce of the dense viscid sputum should then be poured into a Beaker glass (I have found a small evaporating-dish answer equally well, and it is much less likely to be broken), an equal bulk of the solution of caustic soda added, the vessel placed upon one of the rings of a retort-stand (or supported by a stout wire ring held in the hand), the flame of an alcohol lamp applied beneath, and the mixture gradually raised to the boiling temperature, stirring it constantly in the mean while with a glass rod. Dr. Fenwick remarks that generally the expectoration requires an equal quantity of the soda solution to dissolve it; but if the mucus is unusually tenacious more will be necessary. This I have rarely found to be the case; but if requisite, that is, should the compound fail to become entirely fluid as soon as the boiling alkaline solution has fairly acted upon the tough masses, divided and spread out for the purpose by the rod, the dish may be removed from the flame, one-third or one-half more liquor soda slowly stirred in, and the boiling continued as before. Dr. Fenwick recommends that, as soon as liquefied, it should be immediately poured into a conical glass, and three or four times its bulk of cold distilled water should be added, so that the fragments of elastic tissue "may be at once carried to the bottom;" but, as few of the glass vessels we obtain are sufficiently annealed to bear the sudden infusion of a boiling liquid, it is much safer to partly fill the conical vessel with

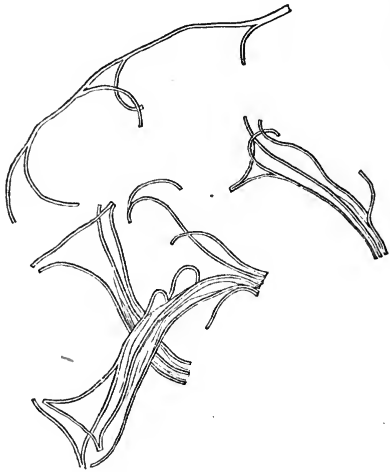
clean water slightly warmed first, and then, stirring in the hot solution, avoid all risk of fracture. As a general rule, the glass and contained fluid should now be carefully covered and set aside for two or three hours; for although Dr. Fenwick states that he has frequently detected the elastic fiber in from six to ten minutes, he considers it advisable to allow a longer time for deposition to take place, at least when there is reason to suspect only a small quantity of the sought-for material; at the end of this time a tube-pipette should be dipped to the bottom of the conical glass, and whatever deposit there exists removed (as directed in Chapter III., p. 68), a drop let fall upon a glass slide, a cover applied, and the whole transferred to the stage of the microscope. Our author judiciously remarks, "Great care should be taken that the dipping-tube is perfectly clean. In one of my earlier experiments I found elastic fiber in the expectoration of a case of recent bronchitis. I had shortly before used the same tube in the examination of some sputa sent by a person suffering from phthisis, and with a new tube I could find no further trace of lung-structure. There is no difficulty in examining the elastic fiber on a common slide, but it is always advisable to use cells; these are best made of vulcanite fixed with cement. The alkaline solution acts rapidly on the marine glue generally used to attach cells. The higher powers of the microscope are never required in this method of examination. I generally use a strong eye-piece, and have an inch and a half and a half-inch object-glass fixed to the instrument by a 'double arm.'"

In regard to the cells thus recommended, their chief object appears to be the enabling an observer to examine a larger quantity of deposit upon a single slide, and this end may be served by using one of the slides with concave centers, furnished by the instrument-makers at $2.00 per dozen, although I have almost always employed

the ordinary glass slip with satisfaction. The magnifying power suggested by Dr. F. is that of about 150 diameters, while my researches have been made with a $\frac{1}{4}$ inch objective and the lowest eye-piece, affording an amplifying power slightly exceeding 200 diameters, my own experience disposing me strongly in favor of using more powerful objectives and shallower eye-pieces, instead of the reverse. The "double arm" or nose-piece referred to is a contrivance for instantly exchanging one objective for another, on the same principle as that employed in the diaphragm plate of the microscope for substituting different-sized apertures. Dr. Fenwick continues: "The amount of lung-tissue varies greatly in different cases. In one I counted as many as eight hundred fragments in mucus that had been coughed up in twelve hours; and we frequently find from fifty to sixty pieces, when from auscultation we should have expected the destruction to be only slight." And again: "The larger bronchial tubes undergoing disintegration are occasionally represented by a simple layer of membrane; but the smaller tubes yield portions of considerable length, exhibiting their branching arrangement. In the majority of cases we meet with all these different forms of lung-structure in a single specimen of expectoration, and we may estimate the rate at which the disease is progressing by counting the particles." According to Dr. Fenwick, "recognition of the various tissue elements is a simple matter," and I have no doubt, to his experienced eye, such is eminently the fact; yet it seems to me that, among us at least, it will often happen that the microscopist unaccustomed to the observation of fragments of lung-tissue will find at first some difficulty in recognizing the structure, and I would advise any one undertaking this branch of research to familiarize himself with the appearance of the bundles of anastomosing fibers which form the walls of the air-cells, by teasing out a thin section of pulmonary tissue, boiling it with

caustic soda, and examining it as above directed. The general aspect of elastic tissue of the lung is exhibited in Fig.

Fig. 19.



Fragments of Lung-Tissue in Sputum Boiled with Caustic Soda. × 220 Diameters.

19, whence an idea of the apparent magnitude of the pulmonary air vesicles may be obtained. It must not be forgotten, however, that in cases complicated or preceded by emphysema (although such are very rare), the air-cells being enlarged, some of the elastic fiber would present a correspondingly altered appearance. Among the most common extraneous matters occurring in sputum are fragments of flax or cotton, which, when frayed out and curled up, as they sometimes are, very closely imitate portions of individual vesicles in appearance; nor is the Y-shaped form (Fig. 20), upon which stress is laid by some, quite characteristic, since this may happen to be simulated

by a couple of fibers which have been split apart for a portion of their length, the other extremities still remaining attached. By accident only, however, could such materials exhibit the arrangement of fibers shown by the smallest fragment delineated in Fig. 19, which seems to be from the junction of the walls of three air vesicles, and I should consider the detection of two or three such particles absolutely pathognomonic of ulceration in the lung. Portions of true elastic tissue from meat employed as food may sometimes, in spite of all our precautions, show themselves in the sputum and complicate the diagnosis. As shown by Dr. Fenwick, the fibers from the fascia of a beefsteak are much larger and coarser in appearance, while those from the peritoneum, as, for instance, the "skin" of a sausage, although more delicate, differ in their entire want of any cellular arrangement. Indeed, I have found this suggestive outline (for it is often nothing more than a hint) of the shape and size of the pulmonary air vesicles, when strengthened by recurrence in several different instances, the most satisfactory evidence that suspected fragments were in reality tissue from the parenchyma of the lung. Another fibrous material which might sometimes lead to fallacious conclusions is the Leptothrix buccalis, whose filaments sometimes grow so luxuriantly in the tartar of the teeth; as, however, they are more slender than the fibers of elastic tissue (Fig. 20), not flexible enough to curl so readily, and rarely, I believe, dichotomous, it is only necessary to be on one's guard to avoid error. Dr. Fenwick figures a portion of vegetable structure which, as he says, could only be mistaken by a *very* superficial observer; but some other vegetable tissues approximate much more closely to elastic fiber in appearance (Fig. 20). Not long since I had brought me, by an attending physician of one of our city hospitals, some boiled sputum in which existed what he suspected were fragments of

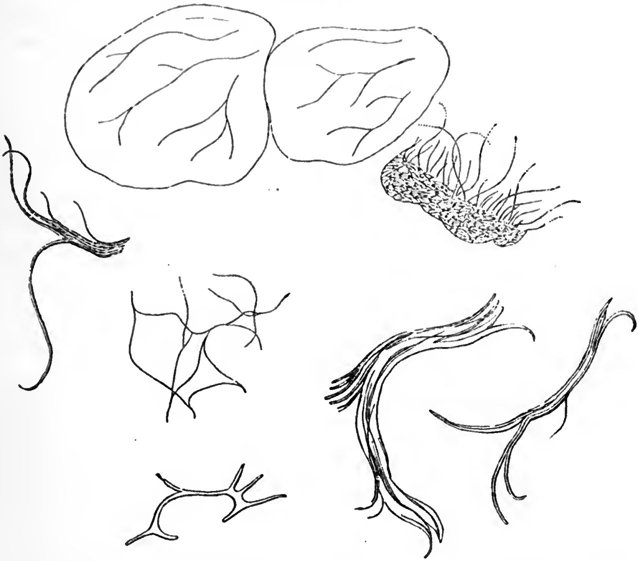
pulmonary air vesicles, and which certainly bore to the latter a very strong resemblance, but proved, on strict scrutiny, to be some minute particles of tobacco-leaf.

After much careful investigation of various specimens of sputum from both hospital patients and cases in private practice, for the purpose of detecting some characteristics of the lung-tissue by which it could be promptly and certainly recognized, it occurred to me that the fibers of the air vesicles, being elastic, must break, like a thread of india-rubber, with a square transverse fracture, while the filaments of any inelastic material, whether vegetable or animal, would *fray out*, as it were, and present to the eye a more or less obscurely *pointed* appearance. Further observation proved my hypothesis to be correct in numerous instances, and I believe that this characteristic of abruptly broken fibers will be found one of the most useful means yet suggested for the recognition of pulmonary tissue in sputum.

It must not be forgotten that these portions of elastic tissue from the lung are only to be found in the sputum while breaking down of the parenchyma is in progress; for example, Dr. Fenwick remarks that he examined after death the contents of a cavity which occupied the whole upper lobe of the lung, the walls of which consisted of a thin layer of lung interposed between a cap of thickened pleura and a dense membrane lining the cavity. The mucus in it showed no trace of lung-tissue. In regard to the varieties of quantity, size of particles, etc., he observes, "The size of the fragments of lung varies greatly, but as a general rule the finer the crepitation the more the smaller pieces abound." "Wherever I have found a marked difference in the amount of lung expectorated at different times, I have found the case eventually to assume a very chronic form, notwithstanding a rapid destruction may have taken place at the commencement of the disease. A man, forty-

five years of age, was admitted under my care at the Victoria Park Hospital in December, 1865. He stated that

FIG. 20.



ACCIDENTAL INGREDIENTS OF BOILED SPUTUM RESEMBLING PULMONARY ELASTIC FIBER.
× 220 Diameters.

Cell-walls of starch granules, filaments of Leptothrix, fragments of vegetable tissues, and split fibers of flax from some muslin fabric, "frayed out" at the ends.

he had been only three weeks out of health. He had great thirst and a dry tongue, pulse 108, dullness on percussion, and mucous râles below the right clavicle. He lost six pounds in weight during the next six weeks, and auscultation afforded evidence of a cavity. In April, when he had somewhat improved, I found 108 fragments of lung in the sputa of twelve hours. In May the sputa still contained lung; but in July I could detect none, and

by the end of that month I could still only find a few filaments. His general health began now to improve, and he remained so well for the next two years that he only lost two pounds in weight. When I last saw him he complained chiefly of dyspnœa; but I heard lately that he had died very suddenly. As a general rule, the increased ulceration of lung is accompanied by increased fever and emaciation, as though the destruction of tissue was a result of pneumonia attacking the diseased part; but in other cases I have found the increased destruction to precede the augmented constitutional disturbance. In some the fever is connected only with bronchitis, and, although the amount of expectoration is very great, the quantity of lung-structures contained in it remains the same. Cases of this latter kind are more hopeful than of the former. I believe the microscope affords at present the only means of distinguishing between them. There is a growing conviction among pathologists that physicians include under the name of phthisis different affections, agreeing only in their tendency to produce ulceration of the lung. We cannot distinguish these affections from each other by auscultation, but we can reasonably hope that the examination of the sputa may throw some light upon this subject. Generally the pulmonary elastic fiber presents under the microscope a clear and well-defined edge. But in some cases it has a dull and very granular appearance, showing that the elastic tissue has itself undergone a change. The number of cases presenting this peculiarity is small; I should say not ten per cent. I have notes of nine cases in which it was present, and in all the disease was chronic. One had suffered from cough for eleven years, originating in whooping-cough; one had had chest symptoms for nine years, one for eight, one for seven, two for six, and two for three years. Six of these were males, and three females; with two exceptions, all were between

thirty and fifty years of age. Seven had hæmoptysis; in one no hæmoptysis had occurred; the history of the other is imperfect on this point. The destruction of lung was very slowly going on in all but one case. We might suppose that in this class the tubercle is a secondary affection; but generally hæmoptysis is the first symptom. I am inclined, from the history and the slow progress of these cases, to believe that a long interval has elapsed between the formation and the elimination of the tubercle, during which the presence of the morbid product has altered the normal condition of the surrounding structures. In others I have found the fibers surrounding the cells greatly increased in number, and, instead of appearing parallel to each other, they have formed a matted, confused layer. This I have only met with in very chronic cases, and I suspect that it indicates a form of disease in which the original morbid change affects especially the fibrous structure of the system."

In regard to the actual practical value of the appearance of lung-tissue in the sputum we have the direct testimony of Dr. Beale and Dr. Bennett, than whom it is probable no higher authorities exist. Dr. Beale remarks, on p. 186 of The Microscope in Practical Medicine: "Dr. Bennett mentions a case in which this elastic tissue was met with at a time when no other signs of phthisis were present. The sputum was examined by Dr. Bennett, Dr. Iliff, Prof. Quekett, Mr. Rainey, and myself. All concurred in pronouncing the substance to be pulmonary tissue. After a time other symptoms of the affection manifested themselves, the physical signs of a cavity became distinct, and the patient died." Again, the same indefatigable observer states in regard to a specimen where fragments of lung-tissue were found in very large quantity: "The amount of expectoration was very small, not amounting to more than half a dozen pellets in twenty-four hours. The

case was that of a stout lady, of about fifty years of age, who had been suffering from cough for about six weeks, consequent upon taking cold. There was slight dullness under one clavicle, but no marked symptoms of phthisis; in fact, it was difficult to persuade the patient that there was anything the matter with her, and the diagnosis rested almost entirely on the fact of the presence of the pulmonary elastic tissue in the pellet of sputum which was subjected to examination." Seeing, then, that the diagnostic value of lung-tissue in sputum has been for many years fully established, by the labors of such microscopists as Van der Kolk, Bennett, and Beale, it seems to me that the statement of Dr. Fenwick in regard to the results obtained by his very ingenious method (which only claims to be a plan for generally utilizing the knowledge we previously possessed, viz., that elastic fibers did exist in the sputa from ulcerating lungs) may be at once accepted as a most important contribution to our information concerning Consumption, and calculated to afford invaluable aid in detecting this terrible disease at that early stage of its course when it is alone (or chiefly) amenable to treatment. Among the cases of pulmonary disease in the Pennsylvania Hospital when examination of the sputum according to this formula was practiced, one of the most remarkable was as follows:—

H. S., a laborer, aged 23, was admitted into the institution on the 28th of September, 1869, for Pleuro-pneumonia, which, although the disease yielded somewhat to treatment and the physical signs improved for a time, was not followed by convalescence. Frequent examinations of this patient's sputa were made, uniformly without the detection of any elastic tissue, however, until a few weeks before his death, when I discovered a single specimen of the cell-wall of three pulmonary air vesicles, which, as there was no evidence of tubercular deposit at either apex, caused

some doubt to arise in regard to the value of this method as a means of diagnosis in pulmonary disease. On the 10th of December, however, the patient died, and at the post-mortem the pulmonary organs were found apparently free from tubercle; but near the base of the right lung a small abscess, not larger than a hazel-nut, was detected, which no doubt furnished the fragment of elastic tissue that had appeared beneath my microscope. The liver was found riddled with abscesses, some of them very large, and probably the immediate cause of the fatal result. (See also case appended to this chapter.)

The statistics supplied by Dr. Fenwick comprise an analysis of 141 cases. Of these he remarks: "In all I have recorded in my notes the history, general symptoms, physical examination of the chest, and the microscopical examination of the sputa. As the cases are taken without selection, they fairly show what amount of assistance the physician may expect to derive from this method of diagnosis. There are no cases of phthisis more difficult of diagnosis than those in which that disease is associated with inflammatory affections of the air-passages. In such the microscopical examination of the sputa has often proved of the greatest value, and in a few minutes has decided the diagnosis. I have notes of twenty-three cases of bronchitis in which phthisis was suspected, either from the general symptoms or from the examination of the chest. In eleven, lung-tissue was found in the sputa; three of these ceased to attend the hospital shortly after the date of the examination, but the subsequent history of the remainder proved that consumption was present. Of the twelve in which pulmonary elastic fiber was not found, six shortly ceased to attend, and the remaining six proved to be cases of uncomplicated bronchitis. As far, therefore, as can be ascertained, although the general symptoms and the examination of the chest gave uncertain results, the

microscope has distinctly indicated the nature of the disease in all.

"When phthisis occurs in persons who have for many years suffered from chronic catarrh, the diagnosis is often very difficult. The resonance on percussion may be abnormally clear, from the existence of emphysema, and auscultation frequently fails to reveal positive signs of the presence of tubercle. The following case is an example of this form of the disease, and shows the value of microscopical examination of the sputa. A man, thirty-six years of age, had been subject to cough for six years, and had suffered from hæmoptysis two years before his admission as an out-patient at the Victoria Park Hospital. There was no dullness on percussion, dry rhonchus could be heard over the whole of the anterior part of the chest, and moist râles were present at the base of the lungs. The expectoration in twelve hours amounted to seven drachms of thin watery fluid; but, when examined microscopically, a considerable amount of pulmonary elastic fiber was found.

"It is often difficult to diagnose phthisis at an early stage, when along with the physical signs of bronchitis the larynx is diseased. The indications presented by the vocal fremitus are not to be obtained; and if there be no distinct dullness on percussion, one is left in doubt as to the nature of the case. The difficulty is still further increased if the occupation of the patient has exposed him to the action of dust or to the prolonged use of the voice. An omnibus-conductor, thirty-seven years of age, came under my care in July, 1866. He had loss of voice, with cough, and a little expectoration, for two months. Pulse 84. I fancied that I could detect a slight diminution in the percussion-note below the right clavicle, but of this I could not satisfy myself. The only sign on auscultation was a dry rhonchus, diffused on both sides of the chest. He brought to me the

expectoration of three mornings, which only amounted to seven drachms of thin mucus. The microscope showed forty-one pieces of lung-tissue in it. Hæmoptysis occurred two weeks afterwards, and his pulse rose to 96. In December, 1866, he had lost in weight seven pounds, and the dullness below the clavicle was distinct. He remained under observation until the following May, but was greatly emaciated when I last saw him.

"Phthisis is often ushered in with an attack of pleurisy. In such cases the development of the signs of consumption is frequently very gradual, and it is only by careful attention to the history of the patient that a correct conclusion can be arrived at. I have notes of some cases of pleurisy in which the slowness of convalescence led to the suspicion of tubercle, but no lung-tissue could be found in the sputa; in all, the subsequent histories proved the disease to have been of a simply inflammatory nature. The following case, however, will show in a positive manner how valuable the microscope may be in the detection of ulceration of the lung. A man, aged thirty-three years, had been subject to cough for fifteen years, and for six weeks had suffered from pleurisy. The microscope detected twenty-seven particles of pulmonary tissue in the sputa. The effusion slowly disappeared. Four months afterwards, mucous râles were detected below the left clavicle. He remained under observation thirteen months, and during the latter part of that time presented all the ordinary symptoms of phthisis.

"I have never detected any pulmonary structure in the sputa of persons affected with uncomplicated pneumonia, although we might imagine that minute portions of lung might be thrown off in this disease. In the following case the microscope enabled me to predict the approach of consumption before any evidence of the presence of tubercle could be obtained by auscultation. A lady had been suf-

fering from pneumonia of the left lung for three weeks before I saw her. She had been losing flesh and strength, but had no cough before the attack. Neither of the medical gentlemen in charge of the case nor myself could detect any evidence of tubercular deposit in the opposite lung. The expectoration was profuse, but no lung-tissue could be discovered in it. Three weeks afterwards, hearing that she was recovering very slowly, I requested that another specimen of her sputa might be sent to me, and in this numerous particles of pulmonary elastic fiber were found. Some time afterwards, physical signs of consolidation were detected at the apex of the right lung; and she died of phthisis eighteen months after the commencement of her illness. This case shows that we ought not to trust to a single examination of the sputa, when the results are of a negative character, but should repeat it from time to time if the symptoms be of a nature to cause a suspicion of phthisis."

"I have noted 27 cases in which, along with cough and expectoration, there were some or other physical signs of consolidation in the upper lobes of the lungs,—namely, a difference in the resonance on percussion between the two sides of the chest, accompanied by feebleness of inspiration, interrupted inspiration, increased expiration, tubular respiration, dry rhonchus, occasional mucous click, or increased vocal resonance. Most of the cases were repeatedly examined with the stethoscope; but with respect to many of them I was unable to satisfy my mind as to whether or not tubercle was present. The expectoration of each was examined only once, and particles of lung-tissue were discovered in 21 cases. Of the 6 in which the microscope failed to find elastic fiber, 2 shortly after ceased to attend at the hospital, 2 completely lost the chest symptoms of which they had complained, 1 afterwards proved to be a case of bronchitis, and the remaining

one was still of a doubtful nature when I last saw it. When I commenced to use the microscope for the detection of phthisis, I was much surprised at the frequency of these cases in which pulmonary structures could be found in the sputa, when, according to the opinion of auscultators, the tubercle was in a crude condition. I suspect that in many of these cases ulceration is proceeding in the deeper portions of the lung, whilst the sounds heard through the stethoscope only indicate the conditions of the parts nearer to the surface.

"I have recorded 24 cases in which there were well-marked stethoscopic signs of 'softening of the tubercle' in the lungs. In every case a single examination showed the presence of lung-tissue in the sputa. All of these proved to be cases of phthisis, and some of them have been under observation for two or three years. As, however, there is seldom any difficulty in the diagnosis in this stage of the disease, the use of the microscope is less needed. The stethoscope indicated the existence of cavities in 43 more cases, and pulmonary elastic fiber was found in the sputa of all. I have mentioned the occurrence of fragments of bronchial tubes and of pulmonary cells when auscultation afforded less serious indication only. I therefore endeavored to ascertain whether there was any variation in the sizes of the fragments of lung in the sputa corresponding with different periods of phthisis. The sizes of the particles were noted in 69 cases, and I found that the proportion of bronchial tubes is smallest when well-marked dullness along with mucous râles show that the cellular structure of the lung is chiefly implicated. The bronchial tubes are of greatest size in the cases presenting the largest cavities."

Dr. Fenwick concludes his very valuable paper with the following judicious remarks: "To the young practitioner it will often be a comfort to confirm by the eye the

diagnosis formed from the evidence received by the ear; while cases are constantly occurring to the most experienced auscultators, in which the aid of the microscope will be of value. The microscope can never rival the stethoscope in its application to a variety of cases, but, like the spectroscope in chemistry, it often attains results in a few minutes that the means in ordinary use require a length of time to accomplish."

It might be supposed that at least during the period of tubercular softening the appearance of so-called tubercle corpuscles in the sputum would aid us in the diagnosis of phthisis; but, as a general rule, when they do occur, we find them mixed with so many Leucocytes (pus and mucous corpuscles), and they have been so far disintegrated, as to be with great difficulty recognized; indeed, even when they are detected, the physical signs and general symptoms are mostly so well pronounced that any assistance in diagnosis is unnecessary. For a definition of the so-called "Tubercle corpuscle," as taught by Prof. Beale, see page 128. In the case of a patient who died of phthisis in the Pennsylvania Hospital on the 28th of February, 1863, I found several specimens, taken from about half a pint of purulent-looking fluid coughed up with a gush the day before his death, composed of "Tubercle corpuscles," as above described, and precisely identical with those found at the autopsy, lining the inner surface of a large cavity near the apex of the left lung.

Of course the discovery of elastic tissue in the sputum can only prove the breaking down of the pulmonary parenchyma, without indicating whether this destruction is the result of disintegrating pneumonic consolidation or of tubercular deposit; and it appears to me, as partly suggested by Dr. Fenwick, that a most valuable field for investigation is now open to the clinical microscopist by the researches of F. von Niemeyer, in regard to the great

comparative frequency of the former condition alone in cases of pulmonary phthisis. According to Niemeyer (Clinical Lecture on Pulmonary Phthisis, translated by J. L. Parke, New York, 1868, p. 11), the products of acute catarrhal pneumonia occasionally, and chronic pneumonia frequently, instead of softening and undergoing absorption, become thickened and metamorphosed into a caseous mass. In cases of the former "the tissue of the lung is not thickened by an exudation rich in fibrin, but by the filling up of the alveoli with young, indifferent round cells. In the most favorable cases this cellular product of inflammation undergoes the same metamorphosis which the fibrin and cells imbedded in it almost always undergo in croupal pneumonia, viz., the cells fill up with fat, degenerate, and the contents of the alveoli, rendered liquid in this manner, are reabsorbed, so that they (the alveoli) become again permeable to air. In less favorable cases the cellular elements continue to congregate in the alveoli, the fatty metamorphosis which has begun in them remains incomplete, and the cells lose their round form and shrink from loss of water to irregular shapes. With these microscopical alterations corresponds the microscopical change from the dull, shining gray, or grayish red, homogeneous condensation of the pulmonary tissue into a dull, yellow, caseous mass, this caseous material (the infiltrated tubercle of Lannec) in a minority of cases undergoing degeneration and giving rise to cavities (a process, of course, accompanied by the presence of elastic tissue in the sputum), which often have a tendency to heal, and, though sometimes giving rise to the deposition of tubercle, have absolutely no *necessary* connection with tuberculosis." Indeed, believing, as Niemeyer does, that "the greatest danger for most phthisical patients is that they may become tuberculous," he ventures to assert, "A patient who, in connection with other symptoms of

pulmonary phthisis, expectorates sputa from whose character we can infer the existence of extensive destruction of the lung, is often in less danger than a patient who is feverish, pale, and thin, and expectorates only tough, transparent sputa," because the former indicates merely the dangerous ulceration of chronic pneumonic deposit, while the latter points toward the more fatal condition of tuberculosis.

While preparing these pages for publication, I have been fortunate enough to diagnosticate one of those obscure cases of acute phthisis (which at first so closely simulate enteric fever) simply by recognizing the lung-tissue in the sputa. In this man, a patient in the Pennsylvania Hospital, I found elastic fiber abundant in the expectoration, about two weeks before the physical signs or general symptoms were sufficiently marked to indicate the disease, and would strongly recommend the method in similar instances as promising more than any other in these difficult problems of differential diagnosis. I am informed by the attending physician, James H. Hutchinson, M.D., under whose care the case occurred, that a full account of it will probably appear in the October number of the *American Journal of the Medical Sciences* for the current year.

CHAPTER XI.

EXAMINATION OF VOMITED MATTERS.

THE examination of vomited materials, comprising as they do the vast number of substances employed as food, presents many difficulties to the young microscopist; and partly on this account, partly from the fact that the contents of the stomach so rapidly undergo change from the solvent action of the gastric juice, our results, with a few exceptions, are neither so satisfactory nor so beneficial in diagnosis as those supplied by investigation of most other evacuations. Still, the use of the microscope in regard to matters ejected from the stomach should never be neglected: since, although its positive evidence is often of but little value, the negative testimony it affords may sometimes be of the highest importance; as in the following instance narrated to me by a distinguished practitioner of our city. In the course of a conversation in relation to the advantages of microscopical research, this gentleman stated that upon one occasion a lady patient, who had been for some months under his care with distressing but ill-defined dyspeptic symptoms, sent for him in great haste, and, on his arrival, exhibited to him a basin containing nearly a pint of greenish-yellow, creamy fluid, precisely resembling pus, which she stated had just been ejected from her stomach. Of course his first impression was that some internal abscess, so deeply seated as to previously have escaped detection, had ruptured into the stomach or œsophagus, to the imminent risk of the

patient's life; but, upon examining a small specimen with a moderate power, instead of the pus corpuscles which he dreaded but fully expected to behold, it was found to contain innumerable oil globules, and proved to be simply the result of an over-distention of the stomach with some indigestible fatty food.

Since vomited matters are commonly made up of numerous different ingredients, more or less isolated from each other, several specimens taken from different portions of the mass will often require examination. If the ejected material is not very viscid, samples may be removed by means of a wide-mouthed pipette, or, if very thick and tenacious, portions may be separated by the assistance of scissors, or a knife and forceps; when obtained, such particles should be deposited upon glass slides, torn out, if necessary, with mounted needles, after being moistened with a drop or two of the vomited liquid or with weak glycerin and water, covered with thin glasses, and examined with a power of from 200 to 1000 diameters. They will often be found to contain numerous fragments of partially-digested vegetable and animal tissues, starch granules (see Fig. 14) from the different farinaceous articles of diet being especially abundant. Care should be taken to examine vomit as soon as possible after its ejection from the organism, since the disintegrative processes already set up within the stomach continue outside the body, and are complicated by those resulting from the development of Torula, Vibriones, and other forms of fungi.

Among the common elements of vomited material may be enumerated,—first, the epithelium of the mouth, which has already been described (see page 47); second, the epithelium of the œsophagus, which is of the pavement variety, having the same general characters as that of the mouth and larynx, except that its component cells exceed the latter in thickness and in the number of their

superimposed layers; third, the epithelium of the stomach, consisting of columnar cells from the lining membrane, and large, polygonal, nucleated cells from the bases of the gastric glands. Dr. Beale states that he has seen large flakes of stomach epithelium ejected by vomiting; in one severe case of scarlet fever, a thin membranous mass, about three inches long by two inches wide, consisting entirely of epithelial cells, was thrown off, and after the patient's death the part of the surface of the mucous membrane from which it was detached, was discovered on opening the stomach. Lastly, the green vomit, so colored by the presence of bile, contains cylindrical epithelial cells, probably from the gall-ducts, besides the other forms of epithelium, with flakes and small masses of biliary coloring-matter, and fat globules. The more accidental elements of vomit comprise muscular fibers, which often, as the process of digestion progresses, exhibit a tendency to separate into horizontal plates or disks, somewhat like the *rouleaux* of the red blood corpuscles, instead of dividing longitudinally, as is their ordinary disposition when torn. (See Fig. 14.) Potato starch granules may generally be distinguished from those of the cereals by their superior size, since they average about $\frac{1}{250}$ of an inch in length by $\frac{1}{400}$ of an inch in breadth. The starch granules of wheat may be most readily recognized after a little preliminary study of a minute crumb of bread or of a few grains of flour; they average about $\frac{1}{800}$ of an inch across, but vary so much in their magnitude that this measurement is of but little value as a means for their detection. Other criteria, more useful for their diagnosis, are their peculiar fatty luster, their frequent marking with a little cross near the center of each granule, and, perhaps best of all, the blue color which the starches all assume when a drop of a solution of iodine is introduced at the margin of the thin glass cover, and reaches their surface. (See page 146.)

One of the most important points of diagnosis in the examination of vomit is the detection of the black or brown material resembling coffee-grounds, which, although not pathognomonic of cancer of the stomach, is yet one of the most valuable signs of that disease. To determine their character and distinguish these brownish particles from fragments of food, one of these little masses which exhibits a reddish-brown tint, should, if possible, be selected, deposited upon a slide, pressed out into a thin film (see p. 199), and examined with a power of 500 diameters, which will probably bring into view the cell-walls of numerous red blood corpuscles, many of them shrunken, pale, and distorted, but a few still showing their normal bi-concave form. There will also be found a considerable quantity of dark-brown pigment, forming small aggregations or minute granules, which probably consist of the altered coloring-matter of the blood. Unless this coffee-ground-like vomit is accompanied with the other signs and symptoms of gastric carcinomatous disease, such as the pain aggravated at night, and, as well as the vomiting, occurring at a particular interval after the ingestion of food, the cancerous cachexia, and the well-marked tumor in the epigastric or right hypochondriac region, it cannot be deemed indicative of anything more than solution of continuity of the internal surface of the stomach, and may point indifferently to simple ulcer, traumatic injury, or malignant disease. Von Düben remarks that the microscope has revealed red blood corpuscles, either in a normal or somewhat wrinkled condition, in the blackish-brown material ejected from the stomach as a consequence of hemorrhagic erosions, of simple ulcer of the gastric coats, of the higher grades of acute gastritis, of epithelioma and of cancer, etc.; the dark color depending in part upon pigment-granules, either free or inclosed by the epithelial cells, most probably the simple result of the presence of

hæmatine. He continues: "The hemorrhagic erosion, as far as we know, gives to the vomited material no other microscopical criterion; but in ulcus ventriculi we have twice observed pus corpuscles: in one case the quantity of pus was so great as to form a thick layer on the filter. We have repeatedly adverted to the great resemblance of pus and mucous corpuscles. We have furthermore stated that the latter are constant elements of vomited material, and we may therefore again caution the observer. Pus can only be diagnosed when the number of corpuscles is very large, when they agglomerate, and when they are constantly present in the vomited material, independent of meals and time." (In regard to the recently demonstrated identity of the mucous, pus, and white corpuscles, with the means for distinguishing when practicable the fluids in which they respectively exist, see pages 114, 162.)

"In cancer of the stomach we have not yet been so fortunate in establishing any reliable microscopical character. It might justly be supposed that if a cancerous ulceration communicates with the gastric cavity, the structural elements of the disease would invariably present themselves under the microscope. This may even occasionally be the case, thereby rendering the diagnosis clear and conclusive; but for various anatomico-physiological reasons this expectation is rather uncertain. Firstly, because there is no specific criterion of cancer; nucleated cells of great size and variable form, in comparison with the fundamental structure of their source, may be admitted as pretty sure indications of a cancerous disease; single fragments of cancerous tissue cannot be admitted as conclusive evidence of cancer.(?) Secondly, it appears even admitted that from a few scattered cancerous fragments a general diagnosis of cancer might be formed by exclusion, but a cancerous ulceration does not follow unless the cancer-cells appear *en masse*, because the disintegration of the cancerous structure may

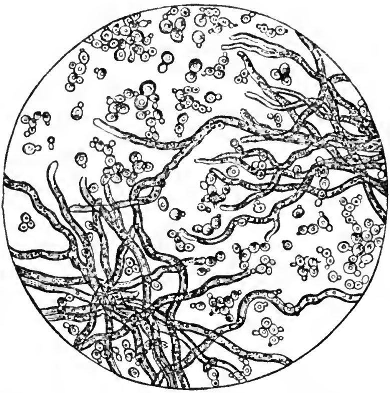
be effected by a fatty degeneration of isolated cells. Thirdly, the surface of so-called cancerous ulceration is invariably covered with a stratum of cells undergoing fatty degeneration, and when in this condition they are so much like ordinary epithelium of the stomach that it seems quite impossible to discriminate between the two. And yet those cells we have chiefly to expect in a raised material."

Dr. Beale confirms the opinion above expressed in the following observations, viz.: "In cases in which cancer of the stomach is suspected, the vomit should always be examined for cancer-cells, although usually these will be so much broken down as not to be recognizable. The observer must be careful not to mistake cells of columnar epithelium for cancer-cells." In order to guard the young microscopist against such an error, I would remark here, that, as will be more fully pointed out in Chapter XV., cancer-cells are to be distinguished from the cellular elements forming the epithelial layer of mucous membranes, not so much by their possessing any particular form, such as the caudate, the oval, or the multi-angular, but by their exhibiting a great variety of shapes and sizes, associated together in close juxtaposition, without order or regularity, as if, the law under which the normal tissues are constructed with similar and methodically-arranged component elements, having been overthrown by the disturbing power of the malignant growth, each particular cell, isolated as regards the mutual relations which it normally bears to its fellows, progresses with its own independent and irregular development, uncontrolled by the force which naturally shapes the constituents of the organ. Further, we may distinguish in many cases cancer-cells from epithelial cells,—first, by the nuclei of the former varying greatly in their relative size and contour, and also in the fact that occasionally two or even three

nuclei appear in the same cell, which circumstance is rare in normal epithelium; and second, malignant disease, especially when actively progressing, presents a great contrast to any epithelial cell formation in its peculiar mother-cells, composed of two, three, or more rounded or oval corpuscles, generally with large nuclei, all inclosed within a single capsule, so as to constitute in effect but one individual cell. In cases where either malignant or benignant tumors, formed within or pressing upon the pyloric extremity, interfere with a natural evacuation of the food from the stomach into the duodenum, and therefore compel its retention within the former cavity for a greater length of time than should physiologically elapse, we frequently find, should vomiting take place some hours after eating, that the ejected material contains innumerable specimens of the Torula cerevisiæ, or common yeast-plant (Fig. 21), whose spores, being introduced in large numbers into the system, in bread, cakes, etc., multiply with great rapidity when, either from want of a free secretion of the gastric juice or from mechanical detention of the semi-digested element within the gastric cavity, circumstances abnormally favor its development. This alga will probably be more readily recognized by the student if he compares it with a few specimens of the growing plant as found in yeast from the kitchen (see Chapter IV.). When once naturalized within the stomach it is sometimes extremely difficult to dislodge, giving rise to most of the symptoms characterizing dyspepsia, by both promoting and causing gastric fermentation. Its spores may be distinguished from red blood globules, which they resemble in size, by their generally oval shape, and by the appearance of granular contents in molecular movement, which the largest ones present under a high power. They differ from fat globules, for which they might be mistaken on account of their fatty luster, in their tendency to aggregation in rows,

each individual joined to its neighbors by the extremities of its long diameter; likewise by their insolubility in ether, which at once dissolves the fatty particles.

FIG 21.



TORULA CEREVISIÆ—YEAST-PLANT. (After Bird, taken from Funke.) × about 200 Diameters.

Von Düben states that one of the most valuable, in fact "the only remedy against it, well known by the populace, is whisky, which chemically disturbs the formation of alcohol" (the alga?).

According to the observations of Prof. C. Reisz, of Copenhagen (*Northern Medical Archives*, Stockholm, 1869; *Medico-Chirurgical Review*, April, 1870), the Thrush fungus, *Oidium albicans*, described in Chapter VIII. p. 166 *et seq.*, is not always limited, as maintained by F. Berg, to the tessellated epithelium of the mouth, throat, and œsophagus, but may occasionally develop among the epithelial cells of the stomach, and there give rise to a "Gastritis aphthosa," with the ordinary symptoms of nausea, pain, and indigestion. See also case reported by Zalesky (*Virchow's Archives*, Band xxxi. p. 426.)

The Sarcina ventriculi was first discovered by Dr. John Goodsir, of Edinburgh, who published a very complete and able report of the case in which it occurred in the *Edinburgh Medical and Surgical Journal*, vol. lvii., Edin., 1842. He describes the plant as follows:

"Sarcina, plants coriaceous, transparent, consisting of sixteen to sixty-four four-celled, square frustules, arranged parallel to one another in a square, transparent matrix. Species 1. *Sarcina ventriculi, mihi,* Frustules 16, color light brown, transparent matrix very perceptible between the frustules, less so around the edges; size, 800 to 1000 inch. Hab., the human stomach." (See Fig. 22.)

In a case where Sarcinæ were detected in the vomited matter, occurring in the Pennsylvania Hospital during the summer of 1869, the attending physician, Dr. J. Forsyth Meigs, suspected at once the existence of the alga from the appearance of the vomit, which, on microscopic examination, exhibited this remarkable vegetable organism in great abundance. The fluid ejected from the stomach, in this instance, was, as described by Goodsir and other authorities, thin, transparent, and almost colorless, while upon its surface floated an abundant scum, reddish-brown in color, and strongly resembling that seen upon beer when a portion of the froth has subsided by standing.

If, in any patient, obstinate vomiting occurs without apparent cause, and the material ejected presents this peculiar brownish froth, either at first or after some hours of repose, the presence of Sarcinæ may always be looked for, and they can generally be discovered by careful microscopical examination. According to Beale, "the vomited matters in which it occurs have usually, but not invariably, very much the appearance of yeast, and fermentation proceeds for some time after they have been ejected. In vomit presenting these characters the Sarcinæ are, I be-

lieve, never absent; but they have been found in other cases and in other situations: by Lebert in a case of cancer accompanied with black vomiting, and by myself in a case in which there was a very abundant ejection of coffee-ground vomit for a few days before death. In this vomit the Sarcinæ were very abundant, but there was no fermentation." They have also been detected frequently in fæces, occasionally in the renal secretion, in cavities of the lung, in the ventricles of the brain, etc. Küchenmeister directs, as a method of observation, that the matter containing the plant should be collected in any convenient manner, allowed to stand at rest for some hours, the deposit removed by means of a pipette, placed upon a slide covered with thin glass, and examined with a magnifying power of not less than six hundred diameters; although for careful study even much greater amplification is useful, I have generally found it quite easy to detect this entophyte with a quarter-inch objective magnifying about 200 times. The fluid in which Sarcinæ flourish has generally an acid reaction, and even in those cases where the bulk of vomited matter is alkaline we will generally find the brown flocculi containing the alga are intensely acid. Although Dr. Goodsir, from the time he first discovered this organism, maintained its vegetable nature, Busk and Link regarded the Sarcina as an animal belonging to the genus Gonium, and Schlossberger asserted that it was nothing more than primitive muscular fiber which had undergone partial disintegration. Virchow, however, proved that the cubes of Sarcinæ were much larger than any which could result from the decomposition of muscle, and also that the muscular fiber entirely disappeared when macerated in water or in acetic acid, whilst Sarcinæ remained. In regard to the hypothesis that it is a product of animal tissue which has undergone a sort of fatty degeneration, any one can satisfy himself of its fallacy by digesting the plant in sul-

phuric ether, which is without action upon it. According to Sir Thomas Watson (Practice of Physic, p. 881), Dr. Budd believes the disease to consist essentially "in some organic change which prevents the stomach completely or readily emptying itself, and which causes a secretion from the coats of the stomach, capable, when mixed with the food, of undergoing or of exciting a fermentative process, and that the development of the Sarcina bears to this fermentative process, or to some stage of it, the same relation as the development of Torula bears to simple alcoholic fermentation." Indeed, both Mr. Berkeley and Dr. John Lowe are of the opinion that the Sarcina is only a very common microscopic fungus in a very peculiar form, and, according to Dr. Beale, Dr. Brinton and Dr. Tilbury Fox regard it as a modification of Penicillium, and, therefore, an ordinary mould, in which view, however, he cannot agree.

FIG. 22.

SARCINA VENTRICULI, FROM VOMIT. (After Beale.) × 215 Diameters.

a. Sarcina. *b.* Starch granules, partially dissolved and rendered transparent. *c.* Minute oval fungi, usually present with Sarcina. *d.* Vibriones. *e.* Oil globules. *f.* Starch (wheat) globule, from bread, cracked but not yet softened.

Dr. Beale states that "various plans of treatment have been employed to prevent the development of Sarcinæ, but hitherto with very imperfect success. Hyposulphite of soda has been found advantageous in some cases, but the disease was not cured. Great relief to the burning sensation which frequently occurs in these cases is experienced by the use of large doses of common salt." Prof. George B. Wood (Practice of Medicine, vol. i. p. 596) remarks: "The sulphite of soda may be given in the dose of a drachm three times a day or oftener. But it is obvious that the cure must be effected, if at all, by measures ad-

dressed to the pathological condition of the stomach. I have had under my care a similar case (of yeasty vomiting) in the Pennsylvania Hospital, which was discharged apparently well, after a treatment of several months with nitrate of silver. The presence of an acid in the gastric liquors favors the production of the Sarcinæ, which cease to appear when the liquid is rendered alkaline. Dr. Geo. Budd has found creasote useful in yeasty vomiting; and common salt has also in his hands proved destructive of the fungus." The cases coming under my own notice have generally been either greatly relieved, or apparently cured, by perseverance in the use of sulphite and bisulphite of soda, creasote mixture, etc., as directed by Prof. Wood.

CHAPTER XII.

EXAMINATION OF ANAL, VAGINAL, AND UTERINE DISCHARGES.

THE constituents of fæcal and other evacuations from the bowels, comprising as they do so many different articles of food, altered in such a variety of ways and degrees during the process of digestion, are sometimes absolutely unrecognizable even to the skilled observer, and of course present many problems of extreme difficulty to the inexperienced microscopist.

As in some instances the detection of red blood corpuscles or of Leucocytes will throw important light upon the case, it is advisable that the specimen of fæces to be examined should not be brought in contact with water or urine, lest its cellular elements undergo alteration by the process of endosmosis; a minute fragment, perhaps the size of a small pin's-head, should therefore be placed upon a slide, and broken down with mounted needles, in a drop of weak syrup or glycerin and water of the sp. gr. of 1028 (see page 37), until it is reduced to a perfectly fluid consistence, when it should be covered with thin glass and subjected to examination upon the stage of the microscope, with a power of 250, or preferably of 500 or more, diameters.

The detection of red blood corpuscles in fæces prepared with the precautions above detailed is, as a rule, easy in an inverse proportion to the distance within the anus that they have been effused, and the consequent length of time

they have been exposed to the solvent action of the intestinal juices; that is, if hemorrhage has taken place, from ulceration of the bowel, mechanical injury, or any other cause, within the rectum or colon, the disks will generally be found to maintain, in a great degree, their normal shape and color, while should the sanguineous discharge have occurred higher up in the ilium, and *a fortiori* in the jejunum, the globules will often be so far disintegrated that they are scarcely recognizable. When such is the case, assistance may often be obtained from the use of solution of aniline, which frequently suffices to bring the distorted or fragmentary cell-walls (see page 176) of the decolorized and broken-down globules into view. The pathological indications of blood in the stools of course vary greatly with its amount, accompanying symptoms (such as pain, soreness, elevation of temperature), and with the history of the patient. Thus, for example, if the disease is of recent origin, the pain felt near the fundament most severely at the time of going to stool and shortly afterwards, and the amount of blood small, careful examination should be instituted for fissure of the anus. If the flow of blood is abundant, internal piles may be suspected; if the red disks are mingled with a great quantity of Leucocytes, and especially if the patient is of a tuberculous diathesis, fistula in ano must be searched for; and should the disease be of long standing, the pain aggravated at night, and the so-called cancerous cachexia at all marked, suspicions of carcinoma of the rectum or colon may be entertained. When the sanguineous effusion occurs from some point higher up in the intestines, the abdominal seat of the pain, the liquid character of the frequent discharges, and the more disintegrated state of the corpuscles will all point to the more internal position of the disease. On the other hand, microscopic examination sometimes affords important aid to diagnosis, by enabling us to exclude the considera-

tion of true melæna, in the investigation of fæcal matter, colored black by the internal use of iron, green by the administration of mercurials, or of indigo, and by the excessive secretion of bile; or red by the ingestion of blackberries, raspberries, etc., or the medicinal employment of Hæmatoxylon and its preparations, etc.

The occurrence of pseudo-membranous or mucous formations in the evacuations of the bowels, although not very common, at least in this city, is apt, when it does take place, to cause no little anxiety to both patient and physician. In a case I saw in consultation some years since in Western New York, the patient, a middle-aged married lady, as well as her doctor, was firmly convinced that the tubular membranes discharged were portions of her bowels, which were ulcerating rapidly away; and so strong was this impression that my positive assurance, founded on careful examination of several specimens (in which I was able to establish the existence of an obscurely fibrillated and granular material wherein a few epithelial cells and mucous corpuscles were *imbedded*, without any of that regularity of arrangement which characterizes the epithelial layers of a mucous membrane), only in part persuaded her that her agonizing dread lest her "insides" were all coming away piecemeal was unfounded. Dr. Beale remarks, in regard to these mucous casts, that they sometimes form complete tubes, and that flakes, some of which are very firm, are common enough, especially after prolonged constipation. He details a case in which tubular casts of this nature were passed by a child four years old, without giving rise to any urgent symptoms. On microscopic examination, the tissue was found to be composed of very firm mucus, in which numerous cells of epithelium from the large intestines were imbedded. (See also references to similar cases of fibrinous casts found in the lacteal ducts of the female mammæ, and in the bronchial tubes of

the lung, on page 173.) Dr. Bennett, in his work on Clinical Medicine, observes: "In a disease very common in Edinburgh, especially in women, flakes of membranous matter are thrown off in large quantities; these present a very similar appearance to the cholera flakes just noticed," viz.: "mucus in which the débris of epithelial cells is entangled; and as the nuclei of these cells resist disintegration for a long time, these round or oval bodies generally exist in considerable number." Von Düben asserts that the discharges in dysentery are characterized by blood and pus corpuscles, either isolated or connected in membranes by a coagulable material.

Among other ingredients of the intestinal evacuations which may be mistaken for these membranous flakes, at least on a naked-eye inspection alone, may be mentioned the skins of various fruits and vegetables employed as food; an interesting example of this kind being narrated by Dr. Bennett, as follows: "An individual was supposed to be laboring under dysentery from the frequent passage of yellowish pulpy masses in the stools, accompanied with tormina and other symptoms. On examining these masses with the microscope, I found them to consist of undigested potato-skins. On inquiry, it was ascertained that this person had eaten the skins with the potatoes. On causing these to be removed before dinner, the alarming appearance ceased, and the other symptoms also disappeared."

According to Von Düben, "Gelatinous, mucous, and rice bodies sometimes occur in alvine evacuations. They are secreted by the follicles of the large intestine, and they characterize themselves by the presence of small round or oval, pale and granulated cells, besides numerous isolated granules imbedded in the amorphous mucus." The microscopical discrimination from ingesta may have some interest and value in the treatment of infants. The recognition of pus in the evacuations of the bowels is necessarily

extremely difficult, few cases occurring in which a sufficient quantity of the liquid can be obtained free enough from fæcal matter to admit of the application of chemical tests, such as nitric acid or liquor potassa, by which alone we can discriminate with certainty between mucus and pus. Sometimes, however, a small streak of dense yellow liquid filled with Leucocytes, occurring constantly upon one particular side of a cylindrical mass of hardened fæces, will point to an ulcer or the mouth of a fistula, and so contribute to the accuracy of diagnosis.

In the alvine dejections of typhus, typhoid, and some putrid fevers, crystals of Triple Phosphate are frequently met with in great number; also, as stated by Dr. Beale, altered blood, and vast numbers of Vibriones with different kinds of vegetable fungi, are not uncommonly found. Among these occasionally occurs the Sarcina ventriculi. (See page 231.) Dr. Bennett relates the following example of a vegetable production developed within the alimentary canal. "On one occasion a dispensary patient brought to me a membranous mass which had been evacuated by the bowels. It resembled a piece of boiled fine leather, of a greenish-yellow color and fibrous structure. On microscopic examination it was found to be made up of an inextricable mesh-work of confervoid growths, consisting of long tubes with joints and a few oval sporules, the former having a great tendency to break across." Von Düben remarks that the fragments of typhus scabs (Enteric fever?) characterize themselves by densely-grouped molecules, derived from decaying cells and nuclei, besides crystals of ammonio-magnesian phosphates.

Among the Infusoria said to occur in the intestines may be mentioned the species discovered by Malmsten, of Stockholm, and named by him Paramœcium Coli. It is described as being about $\frac{1}{250}$ of an inch in length, oval in

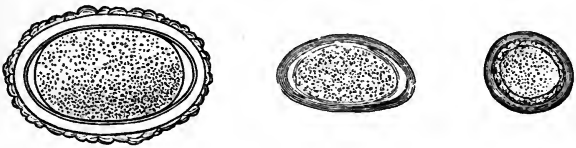
form, containing a nucleus, and covered externally with cilia. Prof. Malmsten believes that the immense numbers and restless activity of these parasites render them well calculated to increase peristaltic motion and intestinal secretion, and consequently to cause diarrhœa. He suggests that the fact that they have not been noticed more frequently before is probably no evidence of their rare occurrence, but owing to their rapid decay after they leave the rectum. As suggested by Von Düben, "It is therefore a material condition in respect to microscopical examination, that the fæces should be submitted to it without delay, unless—and this is preferable—mucus from the rectum be taken."

The microscope may often be called into requisition to determine whether bodies resembling intestinal worms are really portions of Entozoa from the alimentary canal, and especially is it of service in the recognition of the ova of these parasites.

Of the Entozoa, probably by far the most common are the *Ascaris lumbricoides* (Long round worm), classed by Küchenmeister (Manual of Parasites: Sydenham Society's translation, London, 1857, vol. i. page 409), following Dujardin, as a nematode worm, and described as having a white or yellowish, nearly cylindrical body, attenuated at each end, with four whitish, opaque, longitudinal striæ, equidistant from each other; the skin is marked with transverse grooves, somewhat resembling those of the ordinary earthworm, but very much closer together. The head is at the smaller extremity, and may be recognized by its three prominent papilla, which act as suckers during life. The male is smaller than the female, averaging about five inches in length, and is characterized by his comparatively slender, sharply-curved tail, near the extremity of which may often be seen a pair of delicate white projecting hairs, the organs of generation. The female averages at least

twelve inches in length, and may be recognized by the external genitals seated about one-third of the entire distance from the cephalic extremity. The ova of this parasite, with which especially a microscopist has to deal, are of a rounded form, about $\frac{1}{300}$ of an inch in diameter when mature, and furnished with a thin but firm envelope. (See Fig. 23, *a*.)

FIG. 23.



a *b* *c*

OVA OF INTESTINAL WORMS. (After Beale and Leuckart.)

a. Ovum of Ascaris Lumbricoides (Round worm), × 370 Diameters. *b*. Ditto of Oxyuris Vermicularis (Seat-worm), × 215 Diameters. *c*. Ditto of Tænia Solium, (Tapeworm), × 370 Diameters.

The Ascaris, or Oxyuris vermicularis, vulgarly called the thread or seat worm, is the smallest of this class of parasites, the male not averaging more than one-sixth, and the female not more than half an inch in length; the head is furnished with a three-lipped mouth, which is rounded when contracted, and triangular in an active state In addition to the characteristic of size, the sexes may be distinguished by the shape of the tail, which is sharp in the female, while in the male it is obtuse and twisted into a spiral form. The eggs are light, oblong, somewhat irregular in shape, and measure from $\frac{1}{400}$ to $\frac{1}{200}$ of an inch in length. It must not be forgotten that these minute worms sometimes desert their usual seat in the rectum and enter the vagina, where they may give rise to very severe irritation, the true cause of which, microscopic examination

of the leucorrhœa-like discharge, by revealing the eggs or larva therein, may at once disclose.

The Tænia Solium, whose wonderful life history has been so carefully investigated by the great German helminthologist, can hardly be classed among microscopic objects, since its joints may almost always be recognized, on careful inspection of stools in which they exist, with the unassisted eye. According to Von Düben, the ova of Tænia Solium (Fig. 23, *c*) are almost circular, of 0·033 mill. ($\frac{1}{750}$ of an inch) in diameter. (Küchenmeister gives the dimensions as follows: "Eggs, 0·036 of a millimetre in length by 0·036 to 0·043 of a millimetre in width.") "The membrane (capsule ?) upon the application of a low power and false focus shows parallel lines which cross each other at right angles; with considerably increased power we notice that the exterior coat consists of hexagonal parallel plates, with dark spots in the center. In most of them we found embryonic hooks. The presence and the general structure of the ovum are sufficient for the practical purposes of diagnosis." In making an examination of fæces for the entozoa or their ova, he advises that the medical attendant should administer to the patient, in whom they are suspected to exist, a drastic cathartic, and on its operation subject the excrement to careful microscopic examination. The ova are usually found in the mucus, which should be investigated with a low power, of say 100 or 150 diameters, to enable one to make a rapid search, and on discovering an object resembling any of the figures above given, a higher objective should be screwed on, and the structure carefully examined.

The same author justly remarks that "the public is readily disposed to take everything that passes the anus for an intestinal worm which presents an unusual appearance, and we have received many objects for examination which have been sent with this view. In two cases we

found fragments of linen imbedded in mucus and fæces. Mere washing revealed their nature. A pretty thick linen thread, cut into inch-long pieces, had been swallowed by a child and passed off in three or four days. The frightened parent was, however, comforted by our showing the fibrillæ of the thread. In another case, cellular tissue was the cause of alarm, which was of course at once recognized by the microscope. Again, the same element derived from meat-balls was presented to us. In another instance a number of small, white, equally wide pieces were handed us, which by appearance looked as much like tapeworm as could be imagined. The magnifying glass, however, sufficed to destroy the supposition, and the microscope disclosed the true nature of lichen islandicus. In one case Professor Buhl observed mucus to have undergone such changes as almost to simulate tapeworm. But these exemplifications will suffice. To such delusions we can hardly count the case of Professor Huss, who observed for a period the discharge of fibers which proved to be adipose tissue very like that of lipomas. We doubt whether these elements had been introduced from without, and indeed if they were we should be unable to account for their true nature. Perhaps they originated in a lipoma of the intestinal canal disintegrating and passing off in fragments."

The occurrence of fatty matter in the stools, either in the shape of microscopic oil globules or molecules, or in masses visible to the naked eye, is not very uncommon, and is usually attributed to derangement, functional or organic, of the pancreas. In a case which came under my own observation a few months since, the patient, a young gentleman about seventeen years old, experienced intense pain in the rectum during and subsequent to each evacuation, which was accompanied by a discharge of whitish semi-solid matter. On microscopic examination of portions

of this substance, it was found to consist of columnar epithelium, mucous corpuscles, etc., from the alimentary tract, imbedded in a translucent, highly refractive material, which, on the application of a few drops of ether, introduced at the margin of the cover, was seen to be readily soluble in that reagent, and on testing a larger quantity in a similar manner its oleaginous nature was fully demonstrated by its free solubility and subsequent deposition in distinct oil-drops, when a little of the ethereal solution was allowed to evaporate upon a clean slide. The microscopic investigation here, as far as the difficulty near the anus was concerned, was chiefly valuable in disproving the presence of pus, which had been deemed extremely probable from the naked-eye appearances, and upon which a provisional diagnosis of incomplete *fistula in ano* had been predicated.

In the examination of VAGINAL mucus, and other discharges from the vulva, it is advisable, as suggested by Dr. Beale, to avoid the addition of any fluid of lower specific gravity than that of the liquor muci, lest important changes be produced in the appearance and characteristics of the corpuscular and parasitic bodies which they happen to contain; should it be necessary therefore, on account of the opacity of any discharge, to dilute it with a transparent fluid, a weak solution of sugar or glycerin in water (see p. 37) must be employed. Thus, for example, the Trichomonas vaginalis, described by Dujardin and Donné, was for a long time considered by many microscopists to be simply a ciliated epithelial cell (probably because, as observed by Küchenmeister, they examined it during its contact with water, or very weak sugar and water, in which the animals swell up into a globular form and soon become motionless, closely resembling ciliated cells); now, however, it has been shown by Kölliker and Scanzoni that it is unquestionably an independent organism. These gentlemen found it in vaginal (never in cervical) mucus, of

both pregnant and unimpregnated women, especially in the yellowish, creamy, acid mucus, sometimes in neutral but never in alkaline mucus. Küchenmeister states that "it only occurs in women with gonorrhœal discharge, or with an abundant vaginal secretion, mixed with mucous and pus corpuscles; never in normal and healthy fluids of the vagina, but only in pathological conditions. The mucus, however, need not be frothy, as Donné supposes, so long as it is not quite normal. From their granulated appearance, their form, size, and structure, the mucous corpuscles closely resemble this infusorium; they also generally lie in masses together. All these things, with the very sluggish movements of the parasite, have caused it to be very commonly overlooked and confounded with the mucous corpuscles. The prolongation at the anterior end, which is even sometimes drawn out into an elliptical form and furnished with a delicate long filament (*flagellum*), distinguishes the parasite from the epithelium."

The ordinary ingredients of all vaginal discharges of course include the cast-off epithelial cells from the uterine mucous membrane and from that lining the Fallopian tubes; these differ from the squamous cells (similar to those described on p. 47) of the vagina in being columnar and ciliated, a peculiarity which it requires a good objective and some experience in microscopy to detect. Indeed, I would advise the student to familiarize himself on the first opportunity with ciliæ and their remarkable movement, by the study of a few cells scraped from the "beard" of an oyster and examined in a little of the animal's own liquor. In addition to these forms of epithelium and the rounded cells from the numerous glands which occupy the vaginal walls, there appear necessarily during the menstrual period multitudes of red and white blood corpuscles, which, however, present no peculiarities which may serve to positively distinguish them (see p. 175). In the case of Sarah J.

W., a young girl, aged 15, operated on in July, 1870, at the Pennsylvania Hospital (by Prof. D. H. Agnew, one of the attending surgeons), for retention of the menses, the chief changes were a diminution in size and tendency to become granular at the margin exhibited by the red disks (see p. 192).

According to Dr. Beale, in leucorrhœa "many imperfect cells of vaginal epithelium are formed upon the surface of the mucous membrane, as well as pus corpuscles. Many pus corpuscles originate in the cells of vaginal epithelium (?), even after the cells have assumed their distinctive form; but many of the younger cells of vaginal epithelium, and those in the follicles of the mucous membrane, divide and subdivide, giving rise at length to multitudes of the spherical granular cells we know as 'pus corpuscles,' which divide and subdivide very rapidly if freely supplied with nutrient matter." In the light of our more recent knowledge in regard to the origin of pus, however (see p. 154), we are now obliged to modify to some extent these views, expressed by the distinguished English microscopist; considering the abundant Leucocytes not as abortive epithelium, but wandering white blood corpuscles, and their relative number proportioned to the amount of obstruction to the blood-current in the capillaries, rather than to the activity of any proliferating process.

In cases of suspected cancer of the womb it is, as a rule, useless to expect much aid to diagnosis from any examination of discharges from the vulva, since the cellular elements are generally too much disintegrated for recognition. A small portion of the secretion from the os uteri, or from the ulcerated surface of the growth itself, should such exist, must therefore be removed by means of a probe or pair of forceps introduced through a speculum, and on examination with a power of 200 diameters will probably disclose at least a few cells on each slide, which will indi-

cate with more or less certainty the character of the morbid formation (see Chapter XV.).

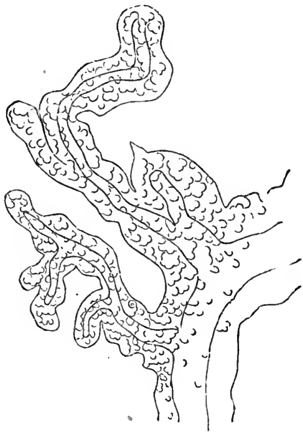
The lochial discharges consist, in their early stage, chiefly of red blood corpuscles, Leucocytes, and epithelial cells from the mucous membrane lining the uterine cavity, either isolated or in flakes of aggregated cells, retaining their normal relations to each other. Later in the puerperal month the first of these ingredients will generally have disappeared, leaving the other constituents in greater or less abundance, according as the discharge approximates on the one hand to the thick, yellow secretion of leucorrhœa or on the other resumes the usual characters of healthy vaginal mucus. Von Düben states that the white (milky) lochiæ contain pus in abundance, and epithelium in the process of regeneration. Exfoliation of the epithelial coats of both the uterus and vagina sometimes occurs, as appears from interesting cases reported by Dr. Arthur Farre and Dr. Tilt, and quoted by Prof. Beale, by whom the membranes are considered to correspond in structure to the layers of cuticle detached from different parts of the cutaneous surface after scarlatina.

I have several times been able to discriminate between mere dysmenorrhœa and actual abortion by careful microscopic examination of a few fragments of such portions of the clotted blood as presented a loose, sarcomatous structure, the branching tufts of the villi constituting the shaggy chorion being, if present, readily recognized under a power of 200 diameters. As the management of cases of dysmenorrhœa and of abortion, both at the time of and subsequently to their occurrence, is quite different, this method may sometimes prove an important aid to diagnosis in doubtful cases, and I therefore append an illustration of the appearance of the placental tufts, drawn, by means of the camera lucida, from a recent specimen. (See Fig. 24.)

I would strongly urge upon the microscopist the im-

portance of studying with high powers the pus of ulcers suspected to be specific, upon either the male or female genitals, as the few observations I have had time and

Fig. 24.



Compound Villi of the Chorion. × 220 Diameters.

opportunity to make tend strongly to confirm the opinion of Donné in regard to the immense number of Vibriones occurring in chancrous pus, a doctrine which, if established, might prove of great value in the diagnosis of syphilis at its earliest stage.

Dr. J. Marion Sims, so well known as for many years the distinguished surgeon to the Woman's Hospital, New York, a comparatively recent proselyte to faith in the revelations of the microscope as invaluable aids to diagnosis, has signalized his conversion by certain very interesting applications of its assistance to the recognition of some of the different causes of sterility. In his Clinical Notes on Uterine Surgery, New York, 1866, Dr. Sims classifies

among the conditions absolutely necessary for conception, that the vagina shall be capable of receiving and retaining the spermatic fluid; also, that semen with living spermatozoa shall be deposited in the vagina at the proper time; and, further, that the secretions of the cervix and vagina shall not poison or kill the spermatozoa. As the presence or absence of these three absolutely indispensable preliminaries to fecundation can be demonstrated only by microscopic examination of the spermatic fluid and the vaginal and uterine mucus, it becomes obviously a matter of importance to know how best to conduct such an investigation, and I shall therefore give Dr. Sims's own directions, as follows:—

"I have said a good deal about semen and its examination, and it is time that I should say something about the measures preliminary to this. Suppose we wish to examine the vaginal mucus soon after coition,—say within an hour; we direct the patient to empty the bladder just before the act, and to retain quietly the recumbent posture after it. The dorsal decubitus is the best. To remove a few drops of the contents of the vagina, pass the index-finger into it, press the posterior wall downwards and backwards just under the cervix uteri; hold it so for a minute or two; the semen will necessarily gravitate into the pouch made by this pressure; then introduce the nozzle of the syringe along the finger; let it project slightly over the end of the finger-nail, and it will be easy enough to obtain what we want, if there is any semen in the vagina. I am thus minute in explaining this simple operation, because we may fail in it entirely, even when the vagina contains large quantities of semen, if we neglect these minutiæ. And in this way. If we pass the syringe in a hap-hazard manner, and begin to draw the piston, the mucous membrane of the vagina is sucked up into the end of the tube, and thus it is possible for us to slide it around

in various directions without getting a drop of mucus of any sort. But suppose we fail even with properly directly (directed) efforts? Then the left lateral position and my speculum will in a moment show us the whole of the contents of the vagina, and we can with the syringe remove what we want. When we wish to examine the cervical mucus, we should resort at once to the speculum and the proper position. It is well enough then to sponge away all the mucus from the vagina, and especially from about the cervix uteri. We then pass the nozzle of the syringe just within the os tincæ and draw up a drop of its mucus. To do this it is necessary first to pull the cervix forward, so as to look into it to see exactly what we are doing. If the cervical mucus is very tenacious, we may fail to get it away. Then it will at the next attempt be necessary, after introducing the syringe and drawing up the mucus, to pass the left index-finger to the edge of the os tincæ, and slide the end of the syringe on to the end of the finger, without raising it from the surface of the cervix or breaking its suction-power. This may seem to be a little thing to describe so minutely, but really it is a most important matter to do if we expect to be exact in our investigations. The nicety of this manipulation renders it the more important for us to clear away all the vaginal mucus before we undertake it, lest we get some of this drawn up into the syringe, which would of course mar the precision of our observations. Suppose we succeed in this, then we may wish to pass the syringe up for an inch into the cervix, to get a portion of mucus nearer the cavity of the uterus. This operation is quite as delicate and quite as important as the first, and is to be conducted in the same way."

As an illustration of his method of investigation, Dr. Sims relates the case of a lady who, although apparently quite healthy, had been married eight years without off-

spring. "The questions to be answered were, Was the semen normal? Did the secretions of the vagina or cervix poison the spermatozoa? Did these enter the canal of the cervix? The vagina was examined an hour after sexual intercourse. Its mucus contained living spermatozoa in abundance. The cervical mucus was full of them, but they were all dead. On another occasion a microscopic examination, made a few minutes (eight or ten) after coition, proved that the mucus of the cervical canal was full of dead spermatozoa, while in the vagina they were living. Here the litmus test (for acidity) was valueless, but the microscope demonstrated a superabundance of epithelial casts, the result of a slightly congested condition of some portion of the lining membrane of the cervix."

Such observations as those above detailed may appear trifling, or even wanting in propriety, to the uninitiated, but the true votary of science, who recognizes the fact that just as in the macrocosm nothing is so vast that its investigation is utterly beyond the bounds of human intellect, so in the microcosm nothing is too minute to be beneath the power or unworthy the exercise of human research, must ever feel grateful for such contributions to our stock of positive knowledge, not only as being valuable in themselves, but on account of their usefulness, or at least importance, to the race. Who shall say, indeed, especially in view of the history of France under her great First Consul, that some fortunate Old-World gynecologist, simply by changing the reaction of the cervical mucus in an unprolific queen from slightly acid to barely alkaline by means of a grain or so of carbonate of soda, may not preserve the life of a royal spermatozoon, and thereby insure (revolutions permitting) the perpetuation of a dynasty of kings?

CHAPTER XIII.

EXAMINATION OF THE INTEGUMENT AND MUSCLES FOR THE DETECTION OF ANIMAL AND VEGETABLE PARASITES.

Although one great English authority upon cutaneous maladies, with a negative determination which, when of an opposite character, constitutes the praiseworthy quality of perseverance, still refuses to admit the existence of the dermatophytic affections, yet the weight of evidence in favor of this class of skin diseases is so strong that I can feel no hesitation in arranging it with the dermatozoa. Indeed, we see to-day, in regard to Favus, the same old battle fought again which, fifty years ago, was so strenuously contested by Biett and Morgagni on the one hand, and the microscopists on the other, in relation to Scabies, now universally admitted to be due to a minute insect, the Acarus Scabiei; and to the student of human nature it is a most interesting confirmation of the wise king's dictum, "there is no new thing under the sun," to observe how the same doubts, followed by the same objections, were urged against the parasitic character of the itch, that are now put forward in opposition to the vegetable nature of Ringworm or Favus. Thus, Biett, Cazenaze, Lugol, etc. denied that even with the aid of microscopes of high power any insect whatever could be discovered. When, by a succession of lucky accidents, so many observers blundered into seeing the acarus that this position was no longer tenable, opponents to the parasitic theory changed their base of operations, and, admitting the occasional ex-

istence of the insect, stoutly maintained that, instead of being the cause of Scabies, it was a "secretory product" of that affection, and by no means a constant one. Finally, when the *proof* that the whole disease could arise from the deposit of a single itch insect upon the skin of a previously healthy person became incontestable, the anti-microscopists took refuge in the assertion that in such cases "the insect taken from the scabious vesicle, *being charged with the virus, the fluid of the vesicle*, by penetration of the cuticle, inserted this virus and produced the disease, like the inoculation of cow-pox."

In some sections of our country, where Scabies is of frequent occurrence, it becomes a matter of real importance that the practitioner should be able to diagnosticate the affection from other skin diseases promptly and certainly; because, if he do not, some old woman among his *clientèle* will in the course of time happen to be right for once when he is wrong, which isolated fact, being industriously circulated by the local Mrs. Grundy, will result very detrimentally to his practice, and probably cost him more in the end than a good microscope would do. Some years ago I was fortunate enough to decide a case of this kind, near my late residence in Western New York, very satisfactorily, as follows: A little girl, about five years old, was refused admission into a large school, for fear that an eruption upon her neck and arms might be communicated to other scholars, as it was suspected to be the itch, an imputation which the child's family, people of village consequence, resented with considerable asperity. On the girl being brought to me for a decision in regard to the nature of her disease, I soon succeeded in extracting from her skin a full-grown female of the Acarus Scabiei, which, when placed beneath the microscope, showed a specimen of animal life in high activity. This I exhibited to the child's relations and to the principal of the school,

none of whom, after comparing it with drawings of the insect and seeing it crawl upon the glass slide, could doubt that the veritable "Itch-bug" *stood* before them.

When consulted by a patient in regard to cutaneous disease, the great symptom which as a general rule should lead us to suspect *Scabies* is the appearance of a vesicular or pustular eruption between the roots of the fingers and at the bend of the wrists and the elbows,—the itch occurring in these situations at least nineteen times out of every twenty; and if on further inquiry we find that a somewhat similar eruption occupies the belly, the inner part of the thighs, and the flexor surfaces of the knees, and that the itching becomes almost intolerable at night, we may feel a high degree of confidence that our patient is inhabited by the Acarus Scabiei. In searching for the insect, I would advise the microscopist, should he have a choice of cases, to select that of a child under ten years old, preferably a girl, and carefully examine in a strong light the folds of skin between the fingers and upon the volar surfaces of the wrists (as a matter of personal precaution requiring all suspected patients to present themselves during the *day*, when the Acarus, being a nocturnal insect, is not likely to wander off upon the hands of the physician). Should these portions of the body have been badly scratched by the nails, his investigation may fail; but in favorable examples of the affection he will soon find among numerous ordinary-looking vesicles, papules, and pustules, more or less irritated by scratching, two or three inflamed points, each of which has running from its circumference a whitish line from a quarter to half an inch long, either straight or curved into a semicircle. One of these being selected, which, when closely scrutinized either with the naked eye or a hand magnifying glass, seems to be a little thicker and more opaque, so as to appear club-shaped at its outer extremity, it is to be

very carefully slit up with a delicate knife or cataract-needle to its termination, care being taken not to press on the contents of the line or furrow with the back of the needle, which is then to be placed under the little swelling at the extremity of the furrow, the minute particle of matter which constitutes it gently lifted out and transferred to the stage of the microscope, when it will probably be found to present the characters of the itch insect. To the naked eye, this parasite is about the size of a grain of ordinary writing-sand and yellowish-white in color; it is often so active that if placed upon a piece of glass laid over some dark surface, by a fiber of white thread (as a point of departure) its motion can be readily detected without a lens. When magnified, it is seen to be oval, like a tortoise, in shape, and at maturity provided with eight legs studded with hairs, some nearly half the length of its body. If a first attempt to find the insect proves unsuccessful, other furrows (technically called *cuniculi*) should be investigated in a similar manner, until the sought-for discovery is made. In case no burrows or *cuniculi* are visible, some of the vesicles which appear to have been least disturbed by scratching may be slit open, the fluid removed, the cavity scraped out with the point of a knife, and the whole transferred to a slide for examination, taking great care not to crush any of the tiny particles, which may be acari, in the process of removing them from the instrument. In cases of Scabies complicated with Eczema, where both cuniculi and vesicles are apt to be obscured by the crusts of the latter affection, the diagnosis may often be much aided by an examination of the crusts themselves, as recommended by Dr. C. Hilton Fagge in the *Lancet* for April 4, 1868. Pieces of the eczematous crusts from a suspected case, which would form a mass about as large as the last joint of the forefinger, are to be boiled in an ounce of solution of caustic soda (see page 38)

until they are in great part dissolved. The flocculent material is then allowed to subside, the supernatant fluid poured off, and the deposit examined under the microscope. In it may frequently be detected full-grown male acari, the young in various stages of development, eggs, egg-shells, and the débris of all these, any of which, when they occur, of course decide the nature of the complaint. In regard to some mild cases of this malady, Dr. M'Call Anderson remarks: "It occasionally happens that Scabies exists to a very trifling extent, and either gives rise to no itching, or at least the patient says his skin is not itchy. Then, of course, there being no itching, there is no scratching, and there is a total absence of secondary eruptions. It may fairly be asked how such patients ever come under the notice of the physician, seeing that they complain of nothing; to which it must be answered that they often come to, or are sent for by, the physician in consequence of their sleeping in the same bed as a patient who manifestly has, or who is suspected of having, the disease, or for some such reason. In these cases we are sometimes able to say that Scabies is present, owing to the detection of a single typical cuniculus, from which the female acarus may be extracted."

It will probably be often a matter of surprise, on first examining cases of Scabies, to find what a great amount of secondary irritation may be set up in other portions of the body by the burrowing of the female insects and the scratching of the patients themselves. Thus, Dr. Anderson observes: "The appearances which the skin presents in cases of Scabies are due to two causes,—first, to the irritation of the acari, and second, to the scratching to which the patient is driven by the irritation. The former are often scanty and undefined, and require to be carefully searched for; the latter are usually the most striking features of the disease. The most common form of eruption

induced by the scratching is termed a pruriginous eruption, because it resembles so closely the phenomena of the disease termed prurigo; that is to say, the orifices of the follicles become prominent, their summits are torn by the nails of the patient, and the blood which is thus drawn dries up, forming little black spots on the top of the papulæ. This pruriginous eruption is met with in all parts of the body, but in typical cases it is decidedly most marked upon the lower aspect of the abdomen, the inner aspect of the thighs and the forearms, while the upper arms, upper half of the trunk, and the legs are comparatively free. In a great many cases pustules are similarly induced, and these are usually of large size (ecthymatous pustules, as they are termed); when this is the case, the complaint is commonly spoken of as Scabies purulenta. They are almost uniformly present in severe cases in children, whose skins are delicate, on the hands, feet, and hips; so much so that pustules in such situations are almost pathognomonic of Scabies, probably occurring upon the hips of infants from the infection conveyed by the hands of nurses carrying them. Again, when persons with a constitutional tendency to eczema are attacked by the acarus, an eczematous eruption is apt to be called forth by the irritation, which may assume any of the varied forms of eczema, and which presents exactly the same appearances as an eczema called forth by other causes."

The treatment of Scabies should be directed to the destruction of the insects, and to the removal of the eruptions excited by their presence and the consequent scratching; when the latter are very severe, it may be necessary first to allay their irritation by cold sedative applications, such as slippery-elm mucilage, or Goulard's Extract of Lead, before applying any of the ointments for killing the parasite, which are generally, either in themselves or in their mode of application, more or less irritating.

The most effectual remedy for Scabies is sulphur, and in my hands has been almost uniformly successful when faithfully employed in the following combination:

℞.—Potassæ Carbonatis (sal tartar), ʒiij;
Sulphur. Sub. ʒvj;
Adipis, ℥iv.

S.—Rub in well over the whole body (or as much as is affected), for fifteen minutes every night at bedtime, for three nights in succession.

The objections to such an ointment in this disease are its irritating effects upon the secondary eruptions, and its disgusting odor; to obviate the former of these disadvantages, Hebra recommends the following:

℞.—Sulphuris precipitati,
Picis liquida, āā ℥vj;
Saponis Viridis (soft soap),
Adipis, āā ℔j;
Cretæ, ℥iv.

Misce.

Dr. M'Call Anderson greatly prefers for private practice the following:

R.—Styracis liquidi, ℥j;
Adipis, ℥ij.

Melt and strain.

This, he states, is "a clean-looking ointment, it has a pleasant aroma, it kills the acari, and it does not irritate the skin in the least, but, on the contrary, rather soothes it."

The rare form of this disease called Scabies Norvegica, far more serious than the ordinary complaint, is only an exaggerated condition or more advanced stage, due to the same acarus, in people who are extremely dirty; it is so much more severe that cases are reported which proved fatal, from secondary affections.

The sebaceous follicles of the face, and the ceruminous glands of the ear, are often the home of another parasite, the Acarus folliculorum, specimens of which are to be found

in most persons more or less abundantly; they feed only on the sebaceous matter of the follicles, and do not of themselves give rise to any disease, as far as we know at present. To obtain them as microscopic objects, it is merely necessary to squeeze out the secretion from a few of the glands upon a slide, and break it up, with a fine mounted needle, in a drop of sweet oil, when the insects may generally be seen on examination with a power of about 200 diameters.

One of the most important among the microscopic entozoa is the Trichina spiralis, a parasite whose frequency and fatality to human life have of late years attracted much attention, especially since numerous cases of obscure complaints ending in death have been traced to this cause on post-mortem examination. The Trichina appears to have been first discovered by James Paget, in 1835, and was described and named by Professor Owen from specimens obtained from Paget's case. Leuckart, Virchow, Leidy, Küchenmeister, and many others, by their observations and experiments, added to our knowledge of this parasite; but it was not until Zenker, of Dresden, in January, 1860, traced the connection between the eating of ham and sausages "filled with vast numbers of trichinæ," and the development of a fatal disease presenting most of the symptoms of typhoid fever, but depending upon the presence of innumerable entozoa, that we became acquainted with this terrible and previously unknown source of disease. Since that time, however, a great number of cases has been reported, occurring in almost all parts of the civilized world, but especially in Germany, where we are informed by Dr. Jackson (*Amer. Jour. Med. Sciences*, January, 1867) that more than two thousand cases of trichinous infection have been published; this large proportion of the whole number of instances being no doubt attributable to the Teutonic custom of partaking of uncooked pork and other kinds of flesh, in the form of raw sausage, etc.

According to Rupprecht, the first period of Trichiniasis, that of gastro-intestinal irritation, comprises the first week or ten days of the affection. The severity of its symptoms depends upon the amount of infected food ingested, and the rapidity with which the cysts inclosing the worms are dissolved. The first onset generally occurs within forty-eight hours after the parasites enter the system, and is characterized in severe cases by vomiting, diarrhœa, and violent colic, not, however, distinguishable from those presented by gastro-intestinal irritation from other causes. The second period, that of muscular irritation, is generally ushered in by œdema of the eyelids and face, which, though occasionally absent, frequently appears about the end of the first week, accompanied by chemosis, mydriasis, and a feeling of tension in the frontal region and across the root of the nose. Dr. E. R. Hun, of Albany, N.Y., mentions that, in cases observed by him, "about the end of the second week a peculiarity developed itself in the gait of the patient, who walked upon his toes, as if unable to rest his heels upon the floor." Of the constitutional symptoms, the febrile movement is the most obvious, the pulse ranging up to one hundred and twenty per minute, with a temperature of 104° to 106° Fahr., although the skin is often moist, and sometimes bathed in profuse perspiration or covered with sudamina. This excessive sweating is attributed to excitement of the sudoriparous glands from congestion resulting mechanically from the presence of the parasites in the subjacent muscles. A tetanic rigidity and tendency to contraction of most of the muscles develop themselves toward the close of the second week, rendering the muscular tissue swollen, hard, and painful. The patients are said generally to lie during most of this period, which continues for three or four weeks, upon the back, unable to move, and in great suffering. In the fourth or fifth week, when the muscles concerned in respiration become in-

volved, partial paralysis may come on, terminating fatally, or death may occur, with typhoid symptoms.

The third period, or that of convalescence, in more favorable cases, is entered upon during the fifth week, being ushered in by a diminution of the febrile symptoms. The appetite, however, returns slowly; prostration is very marked, and œdema of the limbs, or even general dropsy, apparently from anæmia, frequently manifests itself. Occasionally the hair and nails fall off, and desquamation of the skin may occur.

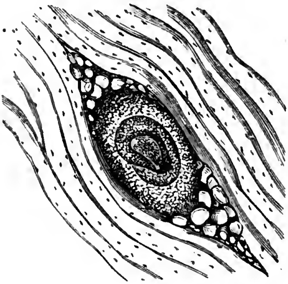
If, then, we are called upon to investigate a case of disease resembling typhoid fever or acute rheumatism, which in the course of the second week presents the peculiar œdema of the eyelids and face above referred to, our attention, if not earlier directed towards Trichiniasis, should be at once awakened to the possibility of its existence, and a most thorough and careful inquiry in regard to the chance of infection by partaking of diseased meat, even if supposed to be well cooked, should be made. In case ground for suspicion in respect to any contamination of meat used as food appears, portions of it, if accessible, should be rigidly examined microscopically; while, to confirm the diagnosis, or should other means of reaching it fail, small portions of some of the patient's voluntary muscles, such, for example, as the deltoid or biceps, should be extracted for investigation, by making an incision through the integument and adipose tissue, after the employment of Dr. B. W. Richardson's local anæsthesia by ether spray, and picking up a few fibers with forceps, or, preferably, by means of instruments resembling harpoons in miniature, furnished by dealers for the purpose. (See paper by Dr. W. W. Keen, *Am. Jour. Med. Sci.*, October, 1869, page 431.)

Dr. Jackson, in his paper quoted above, gives the following description, condensed from various Continental authorities: "The trichina is from $0^{mm}\cdot15$ to 3 millimetres

($\frac{1}{166}$ to $\frac{1}{8}$ of an inch) in length and from 0^{mm} ·03 to 0^{mm} ·05 ($\frac{1}{800}$ to $\frac{1}{500}$ of an inch) in thickness. (Dalton gives the length $\frac{1}{36}$ of an inch, breadth $\frac{1}{100}$ of an inch.)

"When in the larval or encysted state, it is asexual; but on being taken into the stomach it undergoes full development, the female being of greater length than the male, and always being found in proportion to the latter in much greater numbers, by some observers it having been seen to be seven or eight times as numerous. Besides an alimentary canal, the female has an additional tube. opening towards the mouth, which latter is situated at the most attenuated end of the worm, contrary to what the early observers supposed. This tube is the receptacle for its eggs (*sic*), which are developed within her previous to extrusion; the animal is consequently viviparous, and produces, according to Virchow, 200, Gerlach, 400, and, according to Leuckart, 1000 embryos. The young thus born, as stated above, are without sex. It would seem that reingestion by the stomach or bowels is necessary to their development; for if they remain in their encysted state they ultimately perish. Immense numbers of them may be found within a very small space. Dalton observed twelve trichinæ in a piece of muscle the one-twelfth of an inch square and one-fiftieth of an inch thick,—which would give 7200 to the square inch; and we ourselves have, in a piece of muscle weighing one-tenth of a grain, been able to distinctly count 11, giving thus 52,800 to the ounce; a few mouthfuls of food infested at such a rate would afford females enough to generate millions."

FIG. 25.



TRICHINA SPIRALIS, WITH CAPSULE, FROM HUMAN SUBJECT. (After Beale.) $\times$ 40 Diameters.

"The parent trichinæ, after giving birth to their young, are expelled from the intestines; about a week usually after trichinous food has been taken into the stomach, the young animals have been hatched and commence boring into the walls of the intestines, though Fiedler's experiments upon rabbits show that the trichinæ may become sexual during the second or third day, and the embryos quit the mother to commence their peregrinations on the fourth day. They seek the striated muscles as their destination."

"A number of observers have supposed that the young worms reach their ultimate habitat by the torrent of the circulation. Dr. Dalton expresses himself as of that opinion, and in some observations was led to conclude that the cysts were formed within the walls of the capillaries. He thinks the œdema of trichiniasis lends confirmation to his observation, which he says it would be difficult to explain on any other supposition, but is easily understood by an arrest of the circulation taking place simultaneously in so many capillary blood-vessels as must necessarily be obstructed when 7000 trichinæ are contained within the space of a cubic inch."

Virchow, Leuckart, and many others, however, assert that the parasite passes from the intestines to the voluntary muscles solely by vermicular motion. All the striated muscles, except the heart, furnish them a nidus; but they have not been found in the brain, liver, kidneys, or to any extent in adipose tissue. After encapsulation they give rise to no further trouble; the cysts, which usually contain but a single worm, become thickened and hardened, and finally undergo calcareous degeneration, in which state they may preserve living trichinæ for at least twenty-four years. (*London Med. Times and Gazette*, June, 1866.) The wonderful tenacity of life displayed by encysted muscular trichinæ is such that Leuckart submitted trichinous

flesh to a temperature of —13° Fahrenheit for three days without injuring them. Hertwig "boiled trichinous meat, cut in slices the size of one's thumb, for twenty-two minutes without killing the trichinæ, though a continuation of the boiling three minutes longer destroyed them." Virchow showed by experiment that they endured the action of chromic acid for eight days without injury; and accurate observations demonstrate that persons may be infected by pork which has been thoroughly smoked and salted. The only safeguard, therefore, against Trichiniasis is to subject all meat used as food for at least half an hour to a temperature above 170° Fahrenheit; at which point the albumen in the tissues of any entozoa it may contain will become coagulated, and the death of the parasite be insured. According to the very interesting observations of Dr. J. Stockton Hough, late resident physician to the Philadelphia Hospital, Blockley, it seems probable that Trichiniasis does exist in numerous instances in our own country, without being suspected; he reporting four cases discovered in the wards of the Philadelphia Hospital, the first of which he recognized, almost by accident, after death. This first patient was an Irishwoman, aged 28, who died of phthisis, January 16, 1869. (*Am. Jour. of Med. Sciences*, April, 1869, p. 565.) "At the post-mortem examination," he observes, "on opening the chest my attention was attracted to a condition of the pectoral muscles which seemed to be abnormal. On closer examination, calcareous points were noticed in them, but, observing that they were symmetrical in form, and all of about the same size, I concluded that they must be organized. The cysts, on being subjected to microscopical examination, were found to be lemon-shaped and opaque. On breaking one open I found a *Trichina spiralis.* These cysts are from $\frac{1}{75}$ to $\frac{1}{50}$ of an inch long, with a transverse diameter about half as great as the length, and firm from calcareous degeneration. By treat-

ing the opaque cyst with a drop of dilute chlorohydric acid the carbonate of lime is decomposed, and the larval trichina is seen coiled up in various styles. The larval trichina is about $\frac{1}{33}$ of an inch long by about $\frac{1}{700}$ of an inch in transverse diameter. Some cysts contained two worms; all were encysted. The cadaver measured five feet two inches in length, and weighed sixty pounds. The muscle alone is estimated to weigh twenty-four pounds. From these data, counting the number in one grain of muscle, the whole number of cysts were estimated to be about eight millions. All the organs were closely examined, but no entozoa were found in any of them. There were a few in the diaphragm, but none in the heart. This is the first case that has ever been detected in this hospital, and, so far as I can learn, the first that has ever been reported as occurring in Philadelphia."

In a subsequent communication, *Amer. Jour. Med. Sci.*, January, 1870, Dr. Hough states: "Since my report of the two cases of Trichiniasis in the number of this journal for April last, I have detected two more, and am inclined to believe that these entozoa infest the human muscles much more frequently than is generally supposed, and that they may be present in numbers ranging from six to hundreds of millions. I am *positive* that I should not have detected the last three cases had I not discovered the *first* one. Even that was not suspected to be an abnormal condition of the muscles by two of the physicians whose attention was particularly asked in regard to the appearance presented by the muscles. One called them air-bubbles under the fascia, and the other believed the appearance to be due to the cut ends of the fibers of the muscle dried. Unless the trichinæ are very numerous, they will not be detected by one who has never seen them in their encysted state in the muscle; and even then they must often escape observation where their presence is not suspected."

The "Vinegar eel," which resembles this parasite in size and general appearance (see case on p. 147), may be distinguished by its tail being more tapering and sharply pointed than the head of the Trichina, whose caudal extremity equals the thickness of any portion of its body, instead of tapering like the head of the eel to about one-third of its greatest diameter.

The treatment should be conducted, to use that hackneyed and disappointing phrase, on general principles; *i.e.*, since no remedy which will destroy the parasite, and no specific against its effects, have yet been discovered, we must be content to combat the separate symptoms as they arise, and to the best of our ability; relieving the pain by opium, lactucarium, bromide of ammonium, chloral, etc., controlling the vomiting with lime-water, bismuth, or creasote, the diarrhœa with astringent and sedative injections or suppositories, and meeting the prostration by means of tonics, stimulants, and beef essence, as the strongest nutriment.

Doctor Edward R. Hun, of Albany, N.Y., Microscopist to the State Lunatic Asylum at Utica, and one of the most recent authorities upon the subject, in his valuable résumé presented to the State Medical Society (*vide* Transactions for 1869) remarks: "Notwithstanding the various remedies employed, we must acknowledge that as yet no very marked success has been obtained; and this fact may be due to the remarkable vitality of the trichina, as well as its extreme tenuity. * * * * The immense fecundity of this entozoon will also explain how the escape of a few adults from destruction in the intestine may allow of the birth of thousands of embryos. In the present state of our knowledge, we can, therefore, consider the preventive measures as the only efficacious means to be employed against the disease."

According to Dr. Jackson, "the picronitrate of potash, from which so much was expected after Friedrich's cases,

has been demonstrated by Fiedler and others to be of no avail;" we should not, however, be discouraged in our search after the two or three medicinal substances, which probably exist, poisonous to the parasite without being noxious to the individual whom they inhabit, and consequently entitled to be ranked as specifics in this malady.

The cutaneous affections which owe their origin to the development of microscopic plants (Epiphyta and Entophyta) have been very thoroughly studied by Prof. J. H. Bennett, of Edinburgh, and more recently by Dr. Tilbury Fox, of London, and Dr. M'Call Anderson, of Glasgow, to whose work on the subject I am greatly indebted. According to Dr. Fox, the pathognomonic lesion of the Tineæ, as he styles the group of skin diseases which are caused by cryptogamic growths, is a certain altering of the hairs of the part, varying in degree, but present in every instance of fully-developed disease, being least in Chloasma, where the hairs are really unimportant and the fungus chiefly attacks the epithelium, and greatest in Tinea tonsurans, where the capillary appendages suffer most severely. Dr. Fox states that after having performed numerous experiments with diseased hairs out of the body, he has succeeded in getting a hair containing spores which germinated and actually produced the splitting up of the hair and other changes that are observed in ringworm,—in fact, produced "the lesion of ringworm out of the body."

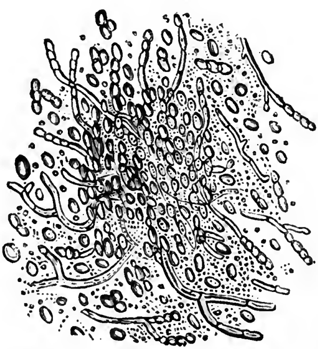
The symptoms presented by a patient consulting us for an eruption upon the head which would lead us to suspect the existence of Favus, are, especially, the occurrence of bright-yellow dry crusts, depressed in the center, through which one or more hairs pass which have a dull, dry appearance and are more easily extracted than natural, the whole exhaling the odor of mice. If, however, the affection is of longer standing, Favus will be indicated (although the crusts may have lost their cup-like shape and bright-yellow

color, and have become entangled in the hairs) by the facts that the hairs are dull, dry, discolored, and easily extracted, and that patches of baldness (apt to be permanent) have appeared. Such suspicions may sometimes be eluded, when well deserved, by the mistaken care of parents in cleansing all the crusts from the head of a child before bringing it for advice; but here the characters of individual diseased hairs will still be apparent, and doubts generally may be solved by directing that the patient shall be brought back after the lapse of a week or two, his head remaining in the mean time untouched. The cup-shaped form of the crusts is invariably assumed when Favus attacks the hair-follicles of the body. Favus of the nails almost always presents itself as a complication of the disease upon the scalp, and, in the rare exceptions when it occurs as a primary affection, sometimes presents no characteristic peculiarities discernible by the unassisted vision.

If a case of eruption upon the head supposed to be *Favus* (*Scall-head, Honeycomb-Ringworm*) be carefully examined, it will be found, should the suspicions be correct, that in an early stage little yellow specks are to be seen, which when examined with a magnifying glass present the appearance of minute bright-yellow crusts, whose central depression is perforated by one or more hairs, and whose base is surrounded by an inflammatory areola which rises above the level of the margin of the cup-shaped cavity. In a more advanced state of the disease these yellow crusts increase in magnitude till they reach a diameter of about one-fourth of an inch, still retaining their rounded or oval form and central depression. The cup-shaped crusts may very readily be removed; and it is remarkable how soon the cavity remaining in the integument disappears, the subcutaneous tissue compressed by the growth of the fungus rapidly recovering its original volume, which it retains until depressed by a new growth of the parasite.

In order to detect the Achorion Schœnleinii, the fungus of Favus, a small portion of one of the yellow crusts may be broken up with mounted needles upon a slide, a drop of liquor potassæ added, the whole covered with thin glass and examined with a power of about 200 diameters. The specimen will be found to exhibit (should the disease be parasitic) an immense quantity of granular matter, the so-called *stroma*, and numerous little bodies about the size of red blood corpuscles, averaging $\frac{1}{3000}$ of an inch in diameter, oval, rounded, or sometimes marked by a constriction, many of them showing an appearance of nuclei in their interior. These bodies are the spores or reproductive portions of the Achorion, and are generally arranged in chains of from three to ten or more, frequently curved and sometimes branched. Besides these, will be seen numerous tubes, often branched, some empty, some with granular contents, either simple or jointed, as if formed by the partial coalescence of a number of spores united at their ends. These tubes vary from $\frac{1}{4000}$ to $\frac{1}{15000}$ of an inch in diameter, and are the mycelia or growing portions of the Achorion. (Fig. 26.)

FIG. 26.



ACHORION SCHŒNLEINII. (After Bennett.) × 300 Diameters.
Fragments of well-developed, branching Mycelia, Spores, and Granular matter, from the center of an advanced Favus crust.

In such a case, the hairs which are readily extracted, and especially those which break off on the application of a slight force, laid upon a slide moistened with a drop of liquor potassæ and examined with a power of from 200 to 600 diameters, exhibit the same chains of spores ramifying upon their surface, and also penetrating

into their substance, the dry, brittle, and discolored condition being apparently caused by the parasitic growth robbing the hair of its proper nutriment and interfering with its development by a more or less severe mechanical compression near the root. (See remarks on Vine Fungus, p. 168.) In investigating a case of supposed Favus for the detection of the Achorion, an inexperienced microscopist will be liable to be misled by the presence of innumerable oil globules, which sometimes arrange themselves in chains of four or five and strongly resemble spores to the unpracticed eye. These oil globules may generally be distinguished by the fact that they vary in size and are almost universally exactly circular in outline; or, if the observer has had some experience in the use of reagents under the microscope, all doubt may be set at rest by acting upon them with Ether, which will at once dissolve them. Another source of error might be the occurrence of red blood corpuscles, which, as stated above, are almost identical in size, and liable of course to be present when the integument has been lacerated by scratching, and if distended into a globular form and decolorized by water (see Fig. 6) are not very unlike spores to the eye of a student; if, however, another specimen is examined in the carbolated syrup (see page 37), red blood corpuscles may be recognized by their bi-concave shape, while the spores will remain unchanged, presenting their ordinary oval and circular outline. As a means of correcting conclusions, it is a good plan to examine a healthy hair, and a few particles of dandruff from one's own head, immersed in a similar menstruum and acted upon by the same reagents; but should the microscopist have the advantage of using a high objective, many of these precautions are unnecessary, a very hasty examination sufficing to diagnosticate between *spores*, *oil globules*, and *blood corpuscles*.

The *treatment of Favus* has been a subject of much

discussion among dermatologists, some authorities, such as Bazin, Hebra, and Anderson, maintaining that nothing short of epilation or extraction of the hair will accomplish a cure, while Bennett, of Edinburgh, asserts that cures may be obtained by constitutional and local treatment with cod-liver oil, the crusts being first removed by the application of poultices; and Erasmus Wilson condemns *in toto* the cruelty of epilation, which he humorously designates "the purgatory of avulsion." The method practiced in the St. Louis Hospital is thus described by Bazin: "Our depilators are seated, and cause the head of the patient to rest upon their knees; with one hand (generally the right) they hold the forceps as one holds a writing-pen; the other hand is applied to the part about to be depilated, with the thumb and finger of which they put the skin on the stretch to keep it steady. They then extract the hairs, pulling them out in the direction of their axes, and only a small number at a time, two, four, or six, or at most a small bundle. It is necessary to avoid depilating too quickly or too gently, there being an intermediate point, which one can only arrive at after a little practice." For two or three days before commencing the epilation the scalp (after cutting the hair to the length of about $\frac{1}{4}$ of an inch) should be thickly smeared with almond oil, or the oil of Cade, either of which diminishes the sensibility of the skin and facilitates the operation. As a general rule, not more than three or four square inches of surface covered by hair can be cleared daily, so that when it is necessary to remove the whole of the hair from the scalp this might be done in a week or so; a longer time of course being required in persons who are very sensitive. After one complete depilation, successive partial operations are frequently requisite, the disease often not being entirely eradicated in all portions of the head; bearing in mind, however, that, after all the spores of Achorion are

destroyed, secondary eruptions sometimes remain, which of course do not require such active treatment. The extraction of the hair by means of the Calotte, a sort of cap composed of strips of strong cloth covered with an adhesive plaster, which, when firmly attached, are violently jerked off, is still practiced in France, but is so severe that instances of death from this cause have been recorded. Among the parasiticides, which are very important as adjuncts to the process of epilation, may be mentioned sulphur and sulphurous acid, turbith mineral and corrosive sublimate, the last of which, in aqueous solution of the strength of two grains to the ounce, is highly recommended by Dr. Anderson, whose experience with carbolic acid was altogether unsatisfactory. Whichever of these remedies is employed must be rubbed into the scalp every time a square inch of surface is cleared of hair, advantage being thus taken of the expanded condition of the hair-follicles to insure the entrance of the parasiticide. A much less painful method, recommended in the *Edinburgh Medical Journal*, September, 1869 (*New York Medical Journal*, April, 1870), is that of removing the crusts, shaving the scalp, and painting over it every night an aqueous solution of chromic acid (ʒj to f℥j) until decided irritation is produced. The application is said to be uniformly successful. In the epidermic variety of Favus, the application of the Corrosive Sublimate Lotion is usually sufficient to accomplish a cure. When Favus attacks the nails, it is advised to file away the portion covering the mass of Achorion, and apply solution of corrosive sublimate directly to the growth. Should the disease in any of its forms occur in patients of a strumous habit, exercise, pure air, cod-liver oil, and preparations of iron are important adjuvants to local treatment.

In the second class of vegetable parasitic skin diseases the prominent symptom which should excite suspicion in

the mind of the medical attendant is the ring-like shape of the eruption, produced by a tendency of the growth to die out in the center after a few days or weeks, thus allowing the skin in that part to regain its health, while the constantly-developing fungus at the margin produces an ever-widening zone of irritation, giving this peculiar form to the disease from which it derives its vulgar name of Ringworm. Dr. M'Call Anderson teaches that Tinea tonsurans or Ringworm of the head, Tinea circinata, Ringworm of the body, and Tinea sycosis, Ringworm of the beard, etc. are all due to the development of the same fungus, which he denominates Tricophyton; while Dr. Tilbury Fox, following Gruby, attributes the latter of these maladies to the Microsporon mentagrophytes. The minute differences, however, are so slight that they will hardly be noticed by most observers, and, as the important point is really, after all, the detection of a cryptogamic growth, the several diseases and the method of discovering them may be described without entering upon this dispute.

Tinea tonsurans, or Ringworm of the scalp, is a contagious disease, generally met with in children, commencing in little points or rounded erythematous patches, which soon take on the ring-like character, and present a circle of scaly, vesicular, or (in persons of very sensitive skin) even of pustular eruption. As the disease advances, the hairs become dull, dry, twisted, and easily broken or extracted, while the epidermis and stumps of the hair become covered with a grayish-white powder, which consists of the vegetable growth. Bazin attaches much importance to the color of the skin in these patches, stating it to be bluish or slate-colored in people of dark complexions, and grayish, reddish, or yellowish in fair persons. When inflammation of a higher grade occurs, small subcutaneous tumors or tuberculated masses are developed, resembling those observed in sycosis. On examining the hairs in

both these affections, the bulbs, except in an an early stage of the disease, are found to be flattened and disorganized, and the hairs themselves have a ragged, splintered appearance, the longitudinal fibers being split apart by masses of spores penetrating between them, while at different points along their shafts nodosities are developed to accommodate masses of spores.

In investigating microscopically a case of supposed Tinea tonsurans, the same method may be adopted which has been already advised for detecting Favus; a few hairs and a small portion of the whitish dust and scaly epithelium of the affected part being moistened with liquor potassæ on a slide and examined as directed, except that a power of 500 or 600 diameters should be employed, taking the same precautions to avoid being misled by oil globules, blood corpuscles, etc. The characteristics of the Tricophyton which are said to distinguish it from Favus are, the minute size of the spores, which do not average more than $\frac{1}{7000}$ of an inch in diameter (less than half that of a red blood corpuscle), and the immense number of these rounded or oval spores in proportion to the mycelial threads or tubes, which are comparatively rare; otherwise the microscopic appearances closely resemble those described under Favus (Fig. 26). The diagnosis from Tinea sycosis and Tinea circinata is to be made simply on the fact of its being seated upon the scalp, instead of upon the face or the body respectively; from Pityriasis, by the presence of the fungus, by the occurrence of the disease in patches more or less circular, instead of distributed over the whole head, by being communicable instead of non-contagious, and by the brittleness and feeble attachment of the hairs, which in Pityriasis are comparatively unaffected; from Psoriasis capitis, by the existence of the fungus, the affection of the hairs, and by the scales being thinner and less silvery, while in most cases of psoriasis patches occur on

other parts of the body, especially the elbows and knees; from Eczema impetiginodes of the head, by the fact that in the latter the parasite is absent, the hairs healthy, the patches of disease not circular, the itching often intense, the affection not contagious and complicated with eczematous eruptions on other parts of the body. In cases where Tinea tonsurans complicates Eczema capitis, the microscopic appearances are the chief aids to arriving at a correct diagnosis, although some assistance may be obtained from the history of the attack and its contagious nature.

Like the Achorion, Tricophyton sometimes attacks the nails, presenting similar appearances, except that the mass of fungous growth is of a grayish-white color, instead of a yellow tint; such cases are, however, rare.

Tinea circinata (Herpes circinatus, Ringworm of the body) generally commences as a little, rose-colored, slightly elevated spot, which in a few days becomes the seat of slight furfuraceous desquamation, and is accompanied by itching or tingling; after a time the center of this spot heals, while the circumference, constantly enlarging, may attain a diameter of four or five inches, its margin being composed, according to the patient's susceptibility to irritation, of a ring of erythematous, vesicular, or pustular eruption.

The microscopic examination is to be made as directed above, extracting, if possible, a few of the fine hairs, and scraping off with a sharp scalpel some of the epithelial cells which constitute the upper layer of the epidermis or have already desquamated. A power of 500 diameters should be used, with which isolated spores, chains of spores, and a few mycelial threads may be seen ramifying among the epithelium; but in order to verify his conclusions the student should examine some scrapings of skin from a corresponding portion of his own body.

The diagnosis from Erythema circinatum is to be made by the existence of the parasite, the history of the case, the contagious nature of the disease, and the distinct elevation which generally characterizes the ring of Tinea circinata; from an erythematous syphilitic eruption, by the history of the case and absence of other secondary symptoms, by the presence of the fungus, by the tendency to itching, and by being asymmetrical in its occurrence; and from Favus of the epidermis, by the smaller size of the spores, the much greater magnitude of the rings, the whitish instead of yellow color of the scales, and its association in most instances with well-marked ringworm instead of Favus of the head.

The circular variety of Psoriasis, when passing off, and after the thick white scales have fallen, may resemble Tinea circinata, but can generally be distinguished by the absence of the fungus, the history of the case, and the occurrence of similar patches upon the knees and elbows.

Tinea sycosis commences in typical cases in small erythematous spots, which have a tendency to heal in the center, and spread at the circumference, leaving rosy circles, or segments of circles, covered with furfuraceous desquamation. Many of the hairs in the affected surface are broken off close to the skin, while those which remain entire can readily be extracted, and are often covered with a white powder, the spores and mycelia of Tricophyton. At this stage the irritation is not very great; but, as the disease progresses, papules and pustules form at the orifices of the hair-follicles, the deeper structures are involved, so that small indurations occur, surmounted by pustules resembling those of acnæ, and finally, as the cellular tissue becomes implicated, large tubercles appear, and present, on removing their covering crusts, the roughly granulated surface, not unlike the pulp of a fig, from which the name sycosis (*συκον*, a fig) is derived. If the affection proceed still further, the

whole surface of the chin becomes very rough, the hairs break off on a level with the skin, or a couple of lines from it, and at last fall out entirely, while in some cases large segments of circles extend round the front of the neck, beneath the beard, from ear to ear, and similar patches are not uncommon over the top of the sternum, and on the wrist, owing to the patient rubbing his chin with these parts. It must not be forgotten that, as a general rule, when the physician is consulted, this disease is so far advanced that careful examination is necessary to detect the few circles of eruption which remain.

The microscopic examination is to be made as directed under Favus, and the appearances will be found to resemble those observed in T. tonsurans and T. circinata.

The diagnosis of this disease is to be made from Eczema impetiginodes of the hairy portions of the face (impetigo menti) by the presence of the fungus, and its appearance in discrete erythematous patches, while the non-parasitic affection is originally pustular, and strongly tends to become confluent; from syphilitic complaints, by the history of the case, the extensive alterations of the hair, and the presence of the fungus.

In regard to the mode of infection of these three diseases, some very interesting observations published by Prof. J. H. Salisbury, of Cleveland, Ohio, in the *Amer. Jour. of Med. Sci.* for April, 1867, p. 379, and by R. Cresson Stiles, M.D., in the *New York Medical Record*, vol. ii. p. 340, prove that it may readily be conveyed from the lower animals, as cats and mice, to human beings, and render it highly probable that such sources of contagion really account for many cases in which these maladies have hitherto been deemed idiopathic in their origin.

"The treatment of Tinea tonsurans should be both constitutional and local, the former consisting of exercise, fresh air, cod-liver oil, and other tonics; the latter, of the

application of parasiticidic lotions or ointments, preceded in severe or obstinate cases by a more or less complete epilation, as directed under Favus. In addition to the lotion of corrosive sublimate and other remedies (referred to on page 272), the Tinct. Ferri Chloridi, U. S. P., is very effectual, and I have known ointments to accomplish a cure without resorting to the painful process of removing the hair."

The most characteristic indication of *Tinea versicolor*, which constitutes Dr. Anderson's third class of Parasitic diseases of the skin, is the peculiar brownish color, varying in intensity, from which the name of *Maculæ hepaticæ*, or *Chloasma*, is derived. This affection, attributed to the growth of the MICROSPORON FURFUR, generally makes its appearance in little spots about the size of a pin's head, which gradually increase in size, retaining their circular form, but not healing in the center, as is the case with ringworm. Gradually these spots unite, forming upon the trunk large irregular patches, near the edges of which we may usually detect small spots of eruption, which are very characteristic. The skin of the affected surface is scarcely, if at all, elevated above the surrounding parts, but is less smooth than in health, and is frequently the seat of a very fine desquamation, so fine as to resemble dust, and having a slight yellowish tint. The itching is generally moderate, sometimes almost absent, and occasionally very severe, although not specially aggravated at night.

The microscopic examination may be made by scraping off some of the fine, powdery, epithelial scales upon a slide, moistening them with liquor potassæ, and examining under a power of 200 to 400 diameters, taking care to test any supposed groups of spores by the addition of sulphuric ether, which will dissolve the suspicious objects should they be only oil globules; the spores of Microsporon furfur, if present, will be seen of a rounded form from $\frac{1}{5000}$ to $\frac{1}{4000}$ of

an inch in diameter, often clustered together in large masses like bunches of grapes, which are very characteristic; the mycelial threads are remarkable for their length, which peculiarity is best seen if, as advised by Gudden, a small blister is applied to some affected part, and a portion of cuticle thus detached examined under the microscope.

The diagnosis is to be made from vitiligo and from ephelis by the presence of the fungus, the history of the case (non-congenital), and the pruritus, desquamation, and elevation of the skin, all of which, though slight in degree, are generally present; from Pityriasis vulgaris, *seu alba*, by the existence of the parasite, and the small, thin, scanty, and yellowish scales which constitute its desquamation; and from syphilitic eruptions which it may complicate, by the detection of the fungus, and by little spots of eruption about the size of pins' heads, generally to be seen at the edges of its patches.

The treatment consists of the application of the Tinctura Ferri Chloridi, the Corrosive Sublimate Lotion, or some other parasiticide, which should be continued for some weeks after all traces of the disease have disappeared, in order to accomplish a permanent cure. When frequent relapses occur, Dr. Anderson (*op. cit.*) mentions the internal use of arsenic, "persevered in for some time, with a view of changing the state of system favorable to the growth of the vegetable."

According to Gruby, Bazin, Tilbury Fox, and other authorities, the disease called *Alopecia areata* (Tinea decalvans, Alopecia circumscripta) is caused by the development of a fungus named by the first of these observers, who discovered it in 1843, MICROSPORON ADOUINI.

This curious affection commences with a little redness and itching of some small spot upon the scalp, often so slight as to pass unnoticed until the hairs fall out, and the patient is surprised to find a smooth, round, white patch

of baldness upon his head; occasionally several of these occur, and, coalescing, form a spot somewhat serpentine in outline, from which the affection derives its synonym of Ophiasis. It appears to be contagious in its character, and is sometimes communicated to the nails by scratching.

The fungus, which Dr. Anderson, with all his experience in Parasitic diseases, has never been able to detect, is described as consisting of minute not very numerous spores, and mycelial threads, which are more abundant; these ramify among the epithelial cells, and penetrate the interior of the hairs, where they give rise to marked dilatations. I am inclined to think that this complaint is not very rare in our own country, but apt to be passed over without much attention. The only case I have seen, and that non-professionally, was one of two or three which occurred in a large boarding-school near this city. The patient was a young lady, about fourteen years of age, in whom a bald spot, about half an inch in diameter, appeared, without any obvious cause, near the vertex, and, after some months, became again covered with hair. No treatment was instituted, nor was opportunity offered for any microscopic investigation of the case.

In the management of this disease, the parasiticides previously recommended are chiefly to be relied upon; and to the list given above may be added the ointment of the red iodide and the nitrate of mercury, which are advised by Dr. Wilson as stimulants, on the ground that Area must be considered "a kind of paresis of innervation."

As remarked by Dr. T. Fox (*Practitioner*, March, 1870, p. 138), in the local treatment of the various forms of Tinea "the microscope must be constantly used to determine when the destruction of the parasite is effected and the hair-forming apparatus is doing its work fairly, lest we produce irritation that is taken for an increase of the disease."

This chapter upon Epiphytic diseases would be incomplete without a brief reference to the occurrence of Fungous growth in the external auditory meatus, which, although rarely observed, probably takes place in many cases where it has been hitherto overlooked. The symptoms which should direct attention to this form of aural affection are the occlusion of the meatus by a lardaceous mass, somewhat resembling inspissated cerumen, but very adherent to the walls of the canal, which, when it is peeled off, are left more or less inflamed, and in a few days again become covered with the obstructive material. The microscopic investigation should be made by tearing up a minute fragment of the mass with mounted needles, in a drop of glycerin or of liquor potassæ, upon a slide, covering it with thin glass, and examining it with a power of 200 diameters. The two forms of fungus hitherto detected are the Aspergillus nigricans and the Aspergillus flavescens, whose spores and mycelia somewhat resemble those of the Achorion figured on page 269. Both of these plants are delineated in a very interesting paper by Drs. St. John Roosa and Wm. B. Lewis, in the number of the *Am. Jour. of Med. Sciences* for January, 1870, to which the reader is referred.

CHAPTER XIV.

MEDICO-LEGAL INVESTIGATION IN REGARD TO STAINS OF BLOOD, SPERMATIC FLUID, ETC.

THE medical practitioner, when called upon to give evidence before a legal tribunal in regard to stains suspected of being produced by the blood of a murdered person, should, if possible, be prepared to meet the arguments of ingenious counsel (who may affirm that various diseases, as, for example, leucocythæmia, anæmia, etc., might have existed, and so invalidate the testimony) with specimens of blood drawn from the corpse itself and spread out in thin films upon glass slides, and also with spots made upon the identical articles of clothing worn by the supposed criminal at the time of the homicide, in order to have a positive and indisputable standard with which to compare his results. Among the various methods with which scientific research has armed us, for the discovery of blood-stains, may be enumerated—first, the detection of red corpuscles by the aid of the microscope; second, the recognition of crystals of hæmatin; third, its discrimination by means of chemical tests; and fourth, through the investigations of Mr. Sorby, we have, by the aid of the spectroscope, an additional method, claimed to be more delicate than any previously in use for the detection of blood.

From observations of my own (published in the *American Journal of Medical Sciences* for July, 1869), however, it would appear that the first of these methods is the most accurate, and by it we are capable of distinguishing much

smaller quantities of blood than by either of the other plans, which I compare as to their relative capacity, as follows:

"By the intricate and tedious method of M. Taddei (*Fabre, Bibliothèque du Médecin Practicien*, tome xv. p. 264, Paris, 1851), 'a piece of linen or cotton, which hardly contained 28 to 30 centigrammes (between four and five Troy grains) of dried blood, furnished enough for determination of its nature.'

"A plan suggested by Dr. F. Runge, in which the iron of the blood was tested for by ferrocyanide of potassium, is spoken of by Dr. Fleming as being so very delicate that a single drop of blood sufficed for complete detection.

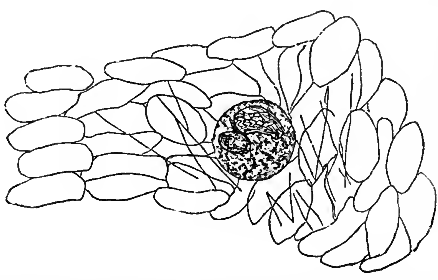
"By spectrum analysis, lately vaunted as successful when ordinary microscopic examination fails, it is claimed that $\frac{1}{1000}$ of a grain of dried blood may be recognized, but no clue is thus afforded to the animal whence the vital fluid is derived.

"Through the courtesy of Dr. Linderman, Director, and Mr. J. K. Eckfelt, Chief Assayer of the United States Mint, I was enabled to estimate the delicacy of the microscopic tests for blood as follows: Upon a square of waxed paper, determined by Mr. Eckfelt on the accurate balance used for the national assays to weigh exactly 48 milligrammes, I made twenty dots of fresh blood from my finger, which, when dry, added ·4 of a milligramme to the original weight, and, consequently, were each on an average equivalent to about ·02 of a milligramme, or $\frac{1}{3200}$ of a Troy grain, nearly. The fourth part of one of these spots, weighing of course in round numbers $\frac{1}{12000}$ of a grain, was detached with the point of a cataract-needle, and when moistened under the $\frac{1}{25}$ showed many hundred well-defined red blood corpuscles. Ten circular ones among these, measured with the micrometer, averaged $\frac{1}{3474}$ of an inch in diameter, and could, therefore, by this

criterion of superior size alone, be diagnosticated from the corpuscles of an ox, sheep, or pig with the same feeling of certainty with which any surgeon could testify that a perforation of the skull only half an inch across could not possibly have been made by a bullet measuring an inch in diameter."

Supposing, now, that the microscopist is applied to for the purpose of determining the character of a comparatively fresh stain resembling blood, he may adopt the following method for examination. Experience has shown that dried spots of blood upon hard smooth surfaces, such as buttons, studs, etc., most readily exhibit the corpuscles; next to these, in ease of detection, are stains upon paper collars or cuffs, and upon highly glazed linen; then those upon unstarched muslin or linen; and lastly, those upon cloth and other woolen fabrics. Should, therefore, the observer be able to discover any well-defined spots upon buttons or studs, let him remove a particle the size of a grain of writing-sand with the point of a cataract-needle,

FIG. 27.



Delicate CELL-WALLS OF RED BLOOD CORPUSCLES, also LEUCOCYTE, showing two nuclei; from fragment of a blood-stain acted upon by water. ×1200 Diameters.

letting it fall upon a slide which has been carefully cleaned. A thin glass cover should then be laid upon the minute fragment, pressed down firmly so as to crush the particle

into powder, and the whole transferred to the stage of the microscope. After finding a suitable portion of clot with a thin beveled edge, pure water should be introduced at the margin of the cover and allowed to flow very slowly toward the chosen specimen; when this is reached by the wave of fluid, a remarkable appearance of boiling up from its center is presented for a few moments, and then, as the tinged liquid is replaced by a clear water, an aggregation of compressed corpuscles (Fig. 27), very faint and colorless, but yet of unquestionable distinctness, becomes apparent, if a lens of sufficiently high power and superiority of definition is employed. A few straight, interlaced filaments of fibrin are often visible, and at intervals the granular, spherical lymph globules occur among the other elements. These white cells frequently become detached and float freely around the edges of the clot, where, as well as whilst still imbedded, they are so much more readily recognized with a low power that I am confident they have often been mistaken for the red disks; indeed, an experienced teacher of microscopy has acknowledged to me that in his own examinations he has sometimes been obliged to rely on the discovery of white corpuscles alone, the red globules, as a rule, escaping detection, a fact which I should attribute to his employment of lenses insufficient in magnifying and defining power for the recognition of the red corpuscle's cell-wall (see page 176). Should a difficulty be found in distinguishing the outlines of the decolorized corpuscles, they may be rendered far more obvious by introducing at the margin of the cover a minute portion of iodine or aniline solution (see page 37), and can then often be distinguished even by inexperienced observers. In making such examinations, "great care must be taken to avoid any movement of the cover upon the slide, which, when it occurs, often rolls the interposed

disks into an apparently homogeneous mass; and it is advisable to keep up a current of fresh water until all tinge of color is removed from the clot, otherwise none but the granular lymph corpuscles may be visible. In order to complete a chain of evidence it is probable that the decolorized corpuscles in a fragment of clot, after being rendered more distinct by iodine or aniline, as above mentioned, might often be demonstrated, if required in court, to intelligent jurymen, especially where, as surveyors, watchmakers, or engravers, the jurors were more or less accustomed to the use of lenses."

Should it be required to determine the character of a stain upon a piece of unstarched linen or muslin, the spot in question should be carefully inspected with a hand magnifier or one of the low objectives, as, for instance, the one inch, and some minute particle, such as can almost always be discovered, detached from among the vegetable fibers by means of a cataract-needle, and deposited upon a slide, the tiniest fragment scarcely visible to the naked eye being often sufficient to exhibit hundreds of corpuscles, which may be detected by examination as above described; or the fabric may be scraped with a sharp scalpel over a slip of glass, the larger particles of lint picked out, and the red dust which remains covered with the glass and subjected to examination.

Blood-stains upon cloth or other woolen material present the greatest difficulties in the recognition of their red corpuscles, and in some cases, where they have been exposed to the destructive action of air and moisture, may be so far disintegrated as to be unrecognizable by this means of observation. The effort should, however, always be made to discover under a hand-magnifier some small aggregation of the corpuscular elements which may be tested in the manner just noted, the great difficulty being to obtain some fragment large enough to have escaped the complete loss

of its liquid ingredients by absorption and consequent compression into a nearly homogeneous mass, while still in a softened condition.

It is almost useless to attempt such an investigation without the aid of superior objectives of high power, viz. of about $\frac{1}{20}$ of an inch focal length. At least, some of the most experienced authorities, working with inferior lenses, have been compelled to acknowledge their inability to distinguish blood corpuscles in the dried clot; for example, Dr. Fleming observes: "From the experiments which I have made during a period of several years with blood belonging to different animals, when dried for a length of time and moistened again, I am forced to admit that great difficulty arises in attempting to fix its origin by the comparative size of the corpuscles;" and again, "that the blood of ovipara, when kept for several weeks, does not present the peculiar elliptical corpuscles found in fresh blood in a form sufficiently perfect to justify me in declaring positively whence it proceeds." And Professor Wyman asserts that "If a drop of blood be rubbed on a piece of glass, as by drawing a bloody finger across it, so that the disks are deposited in a single layer and then allowed to dry, they are readily recognized even in the dried state; but when allowed to dry in masses I have failed to determine their presence; the lymph globules, on the contrary, may be softened out after they have been dried for months, and their characteristic marks readily obtained." According to my own experiments, however, it would appear that "when the disks have not undergone disintegration a first-rate $\frac{1}{25}$ inch objective will enable us to detect their presence easily and beyond all question."

Presuming now that the corpuscles of blood have been recognized, the question, from what animal the fluid is derived, becomes a further problem for investigation. And "although it must be admitted that the blood corpuscles

of a few mammals approach so nearly in size to those of man as to render their distinction doubtful, yet for the practical testing of blood-stains in criminal trials we will rarely find that such a decision is necessary, since, as a rule, justice only requires that a positive diagnosis shall be made between human blood and that of animals which are commonly slaughtered for food, such as the ox, the sheep, or the pig; and of birds, as, for example, chickens, ducks, etc." Drs. Carpenter and Flint, following Gulliver, state that the average diameter of the red corpuscle in

Man	is 1–3200	of an	inch.
Orang-Outang	1–3383	"	"
Dog	1–3542	"	"
Whale	1–3099	"	"
Rabbit	1–3607	"	"
Rat (black)	1–3754	"	"
Raccoon	1–3950	"	"
Red Squirrel	1–4000	"	"
Fox	1–4117	"	"
Pig	1–4230	"	"
Ox	1–4267	"	"
Red Deer	1–4324	"	"
Cat	1–4404	"	"
Horse	1–4600	"	"
Sheep	1–5300	"	"
Goat	1–6366	"	"
Musk Deer of Java	1–12325	"	"

	Long Diam.	Short Diam.
Camel	1–3123	1–5876
Sparrow	1–2140	1–3500
Pigeon	1–1973	1–3643
Cock	1–2102	1–3466
Duck	1–1937	1–3424
Lizard	1–1555	1–2743
Frog	1–1108	1–1821
Perch	1–2099	1–2824

From this table it will be seen that, although "it is

true the older microscopists, who rarely obtained first-rate definition with their lenses magnifying much beyond 500 diameters, were probably wise in recommending that none but the most expert should attempt a decision between the blood of various mammalia, even when fresh, for the difference between an apparent magnitude of $\frac{1}{10}$ and $\frac{1}{12}$ of an inch may well be counted too minute to lightly determine a question often so momentous; yet, as during the last three or four years opticians have furnished immersion lenses of $\frac{1}{25}$ and $\frac{1}{50}$ of an inch focal length, the former rendering the apparent size of a red disk from fresh human blood five-sevenths of an inch, while that from ox blood is but half an inch across, and consequently little more than half the area as seen upon the stage, it seems as if any careful observer might now, with the aid of such objectives, be qualified to pronounce a positive opinion. It has been plausibly objected, however, as by Prof. Virchow, that since the diagnosis of the different species of mammalian blood depends solely upon the relative size of the red disk, variation in the rapidity of desiccation may sometimes cause dried corpuscles to so deviate from the ordinary degree of contraction during that process (which, according to Carl Schmidt, is a constant quantity, 'the drying of blood globules of different animals, isolated or in mass, adhering to the same rule of evaporation as the pollen of a flower, and the coefficient of desiccation in all of them bearing a constant relation to the diminution of their volume') as to lead the microscopist who relies upon the characteristic of magnitude only into serious or fatal error." But, from experiments detailed in my paper, already so largely quoted, it will be seen that the variation in the mean diameters of blood corpuscles dried under various circumstances did not amount to $\frac{1}{140000}$ of an inch. It must be remembered, however, that this applies only to

small spots of blood, and possibly may not hold good with large quantities.

"I would suggest to any one about undertaking such investigations for legal purposes that he first accustom himself to the appearance of decolorized blood corpuscles, and at the same time test the power of his microscope; as detailed above upon a fragment of blood clot recently dried on paper or glass, coloring the outlines by means of iodine or aniline solution, as already suggested," should he find greater distinctness required.

If, from any cause, whether it be want of sufficiently powerful lenses, or too advanced disintegration of the corpuscles through prolonged exposure, the observer fails to succeed in his efforts for the recognition of red blood corpuscles in the dried clot, he may resort to some of the methods described by other authorities for their detection. Thus, Dr. Fleming directs that specimens of dried blood should be examined by placing them upon a slide and cautiously adding water in quantity proportioned to the size of the stain, so as to make a close imitation of the normal serum; or, as very ingeniously suggested by Böcker, we may resort to the use of serum obtained by filtering human or other mammalian blood in the examination of that of the ovipara, and in like manner may employ the serum of frogs' blood to mix with that having round corpuscles. Dr. Alfred S. Taylor recommends that glycerin, diluted with water to the specific gravity of serum (see p. 37), should be used to soften the blood clot, and advises it not only on account of the ease with which it may be obtained pure, but also of the slowness with which it evaporates. Albumen, as presented in the white of the egg, mixed with water until reduced to the proper density, has been found free from many objections urged against other menstrua. M. Charles Robin, the very distinguished Parisian microscopist, advises that a solution of

sulphate of soda should be employed for moistening suspected blood-stains, claiming for it peculiar advantages in retaining the shape and size of the red disks.

Dr. Caspar (Hand-Book of the Practice of Forensic Medicine: Sydenham Society's translation, London, 1861) remarks that by recent discovery microscopical examination permits us to hope that we may be able to recognize blood by its aid, even when the quantity is much too small for its chemical detection. "First of all, we must always ascertain the existence of blood corpuscles, and in satisfying ourselves of this we must not neglect the white corpuscles, since their detection along with the other characteristics considerably strengthens the credibility of the result. In treating dried stains of blood in the usual manner with water, watery solutions of salt, or iodine, etc., very distinct corpuscles are obtained. If many of these, however, are colorless, the probability is very great that it is purulent or muco-purulent matter, or some other pathological product, and not blood. If relatively but few of the corpuscles are colorless, it is all the more likely to be blood; the discovery of fibrin concludes the microscopic examination. This is easily recognized as the material connecting the fragments of blood after they have been for some time exposed to the action of water." This supposed "Fibrin" probably consists in reality of the cell-walls of the decolorized red disks. (See page 176, also Fig. 27.)

MM. Briand, Chaudé, and De Claubry (Manuel complet de Médecine légale, Paris, 1852, page 789) declare that, "however great may be the age of the spots, microscopical examination will nevertheless reveal the blood globules; those on which M. Robin has made his experiments dated back from eight to twelve years.

"But, in order that the micrographical results should be positive, it is necessary that the spots should not have

been washed, or that the tissues on which they have formed should not have been placed, while the stains were fresh, under such circumstances that putrefaction could completely alter them; for it is evident that if the characteristic anatomical elements of the blood are destroyed, it is not in the power of the microscope to make them reappear. Washing destroys the globules, but leaves their elements conglomerated in such a way that we can find some chemical characters when the microscopical ones have disappeared; it is that which obliges us in researches to use a solution of sulphate of soda instead of water for moistening the spots.

"After having cut out with scissors the portions of tissue (linen, hemp, or cotton) to be examined, we place them in a saturated solution of this salt, in which we allow them to remain a longer or shorter time according to their age.

"If the spots are recent (for example, a week old), three to six hours are sufficient for the globules to become separated; but the solution is only imbibed very slowly by fabrics for a long time spotted, and those which date back eight or twelve years require three or four days' soaking.

"When the stuff is completely penetrated, the spots should be scraped with the edge of a scalpel or other similar instrument, and the reddish liquid from them deposited upon a slide and covered with a very thin glass." The authors state that we find fibers of the tissue, granular matters, and a great number of microscopic fungi, to which no attention need be paid, while the blood globules, of which the majority are destroyed by drying, constitute but a small portion of the objects in the field; part of the globules float freely, while another portion adhere to the filaments of the stuff. Many of the former retain their ordinary size and discoid shape, although some have become altered in their contour. Of those which are

adherent, the globules which occupy the edges of the groups alone show their regular form, while the others have become somewhat polyhedral during desiccation. However, the mass always retains a peculiar aspect, which we find in no other anatomical element. Should it be a question whether the blood has proceeded from a mucous membrane, as in a case of rape, the spots of mucus and the epithelial cells become important, since their nature may show what mucous surface has been wounded. When, in consequence of the disintegration of the globules from age, from long exposure to the action of the atmosphere, or from the effects of moisture, microscopical research fails to reveal any of the corpuscular blood elements, resort must be had to the chemical or other methods of detecting blood-stains. Among these, one of the most important is that of Teichmann (Casper, Op. cit., page 199), by the formation of crystals of hæmin, which, it is asserted, will enable us to diagnosticate the presence of blood, no matter what its condition, and although the fabric upon which the stain has been made may have undergone washing. "Büchner and Simon have indeed proved (by this method) the existence of blood in a small rag cut from a butcher's slaughtering trousers, which had been eight years in use, but had not been worn for one year and a half previously." The following is substantially their simplified process: "A drop of blood, or fluid containing its coloring matter, is to be mixed in a watch-glass with an excess of glacial acetic acid; it is then to be slowly evaporated over a spirit lamp, gas jet, in a sand-bath or oven (or spontaneously in the air). When the dried mass is now brought under the microscope, innumerable crystals of hæmin are at once seen, when the coloring-matter of the blood has actually been present in the fluid employed. Sometimes these crystals are isolated; at others, and more usually, they are present in thousands. These crystals are rhomboidal

in form, tabular, or otherwise; their color varies from a faint yellowish to yellow or yellowish-red or a dirty blood-red or still deeper color; their size is various, and they are frequently found placed over one another in a cruciform or stellate manner. When the amount of blood is very small, it crystallizes in such thin tablets and cylinders that they appear quite colorless, and these combine in a very fine reticular form, the meshes of which are extremely close. I obtained a very perfect preparation of this nature from a completely faded stain from menstrual blood, the size of a cherry-stone, which for three months had adhered to a much handled piece of linen. Stains of blood dried upon wood, metal, or stuffs are most rapidly tested by macerating them in glacial acetic acid in a test-tube till the acid is colored, and then evaporating the fluid. When the blood-stains are of long standing, it is better to boil them in the acid in a test-tube till the acid becomes reddish, and then evaporate the fluid."

Among the chemical and physical characteristics by which blood-stains are distinguished from those produced by other substances are the following, as detailed by Dr. Fleming (Blood-Stains in Criminal Trials, Pittsburg, 1861, page 11):

"1. They are soluble in distilled water, and impart to it a beautiful red color, more or less intense as the proportion of the size of the stain and water vary, of a very feeble alkaline reaction, changing the red litmus to blue.

"2. When ammonia is added to the aqueous solution, no *change* takes place in the color, but an alteration from red approaching to brown is found in proportion to the degree of concentration of the ammonia.

"3. When the solution is heated, coagulation takes place, the bright red color is destroyed, and grayish flocculi are found.

"4. These flocculi are quickly dissolved by a solution

of potassa, and the liquid assumes a green tint by reflected and red by transmitted light; the dichroism produced in this manner, according to M. Gaultier de Claubry, is *a certain indication of the presence of blood* (which Caspar, Op. cit., page 198, however, denies). When the solution is very dilute, to produce this phenomenon an advantage will be found in using caustic potassa.

"5. Blood-stains are insoluble in alcohol, ether, and oils.

"6. Dried blood is slowly soluble in strong sulphuric and muriatic acids, forming dark-brown solutions; it is more rapidly acted upon by nitric acid, which dissolves it with effervescence."

The reader is referred to Dr. Fleming's able treatise quoted above for a full description of the methods for testing blood-stains by the detection of their contained iron, as suggested by Runge and Berghauss; by the Hæmatalloscopy of M. Taddei of Florence, and by the recognition of a specific odor announced as very characteristic by M. Barruel in 1829, but not confirmed by subsequent observers.

The same author narrates the following very interesting case as exhibiting the value which a complete microscopical examination, not merely of blood-stains, but of other suspected matters, may have in the detection of crime. The trial occurred at Norwich, England, about the year 1850, under these circumstances: "A female child, nine years old, was found lying on the ground in a small plantation, quite dead, with a large and deep gash in the throat. Suspicion fell upon the mother of the murdered girl, who, upon being taken into custody, behaved with the utmost coolness, and admitted having taken her child to the plantation where the body was found, whence the child was lost in quest of flowers. Upon being searched, there was found in the woman's possession a large and sharp knife, which was at once subjected to a minute and careful exam-

ination. Nothing, however, was found upon it, with the exception of a few pieces of hair adhering to the handle, so exceedingly small as scarcely to be visible. The examination being conducted in the presence of the prisoner, and the officer remarking, 'Here is a bit of fur or hair on the handle of your knife,' the woman immediately replied, 'Yes, I dare say there is, and very likely some stains of blood, for as I came home I found a rabbit caught in a snare, and cut its throat with the knife.' The knife was sent to London, and, with the particles of hair, subjected to a microscopic examination. No trace of blood could at first be detected upon the weapon, which appeared to have been washed; but upon separating the horn handle from its iron lining it was found that between the two a fluid had penetrated which turned out to be blood,—certainly not the blood of a rabbit, but bearing every resemblance to that of the human body. The hair was then submitted to examination. Without knowing anything of the facts of the case, the microscopist immediately declared the hair to be the hair of a *squirrel.* Now, round the neck of the child at the time of the murder there was a tippet or 'victorine,' over which the knife, by whomever held, must have glided; and this victorine was of *squirrel's fur!*

"This strong circumstantial evidence of the guilt of the prisoner was deemed by the jury sufficient for a conviction, and whilst awaiting execution the wretched woman fully confessed her crime."

Within the last few years the detection of blood-stains by spectrum analysis applied to the microscope has attracted a good deal of attention through the researches, in great measure, of Mr. H. C. Sorby (*Quarterly Journal of Science*, April, 1865, vol. ii. page 198, and Beale, How to Work with the Microscope, London, 1868, page 218), who maintains that they can be recognized by this method with great ease and certainty, even when in very minute

quantity. His general plan of operation is founded upon the well-known fact, that different solutions through which the solar spectrum is passed absorb different portions of its constituent colors, and hence give rise to dark lines situated in the red, violet, blue, etc. It is obvious that by testing solutions of supposed blood-stains, first in pure water and subsequently, after the reaction of sulphite of soda, ammonia, citric acid, etc. (which are found by experiment to alter or destroy the absorption bands produced by certain substances, without affecting those caused by others), we have within our power a very complete and delicate method for detecting blood-stains; for the full details of the process I must, however, refer my readers to the articles above mentioned, and, unfortunately, since the method, so far as hitherto investigated, offers no prospect of enabling us to distinguish between the blood of different animals, it can only be of service, as corroborative evidence, when the corpuscular elements are still recognizable in the stain.

As a very delicate test for blood-stains, Dr. Alfred S. Taylor recommends their reaction with tincture of guaiacum and the peroxide of hydrogen, and in Guy's Hospital Reports for 1870, vol. xv., third series, p. 273, Dr. Taylor further states that Dr. John Day, of Geelong, Australia, has improved upon his process above referred to by employing ozonized or ozonic ether in place of the watery solution of peroxide of hydrogen, which is apt to become acid, and then interferes with the reaction sought; he remarks that he has had to make use of this process in many cases, since the date of his former paper, and has found that, under proper precautions, the results are most satisfactory. "The coloring-matter of blood could be detected in cases in which the microscope and the ordinary means of research failed to show its presence." (?)

Mr. H. C. Sorby also furnishes in the same article some directions for the Detection of Blood by means of the spectrum microscope, which, however, require certain explanations, given in Beale's "How to Work with the Microscope," to which I have referred. Although this method of detecting blood-stains is, it seems to me, less delicate than the one I have pointed out, and admittedly inferior to the latter as a means of deciding the important question as to what animal the blood is derived from, Mr. Sorby informs us that the two well-marked absorption bands in the green produced in the spectrum passed through the solution of blood from a fresh stain become fainter, while another band appears in the red whose relative distinctness shows the amount of change, and is some indication of the age of the stain, a point which may be occasionally of great importance in medico-legal investigations, and to which no other method of research that I am acquainted with affords a clue.

In the trial of George S. Twitchell for the murder of his mother-in-law (Philadelphia, 1868), an effort was made to raise the question whether certain stains were not produced by the splashing of bloody water; and from some experiments I made to test this point I conclude that "the discovery in the fluid from a blood-stain (treated with diluted glycerin) of numerous rounded and oval corpuscles, granular to a greater or less degree, and which swell up exhibiting one, two, or three nuclei on the free addition of water, would, in my opinion, justify the microscopist in affirming that the spot had been caused by undiluted or but slightly diluted blood." See *Medical and Surgical Reporter*, Philadelphia, Jan. 8, 1869.

The investigation of stains upon clothing supposed to be caused by spermatic fluid, as in cases of rape, indecent assault, etc., is sometimes of very great importance, and demands the most skillful and accurate manipulation; while

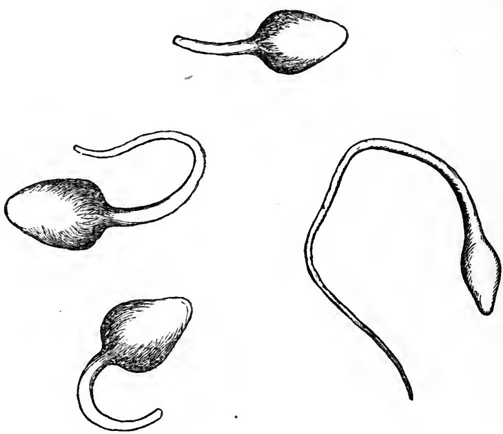
its success is much facilitated by, if not largely dependent upon, the employment of high powers, *e.g.* the $\frac{1}{25}$ and $\frac{1}{50}$ objectives.

In a case upon which I was consulted some time since, where a young girl was said to have been violated by main force and held down for some minutes subsequently, the chemise worn on the occasion was brought to me for examination. On inspection, besides sundry small reddish spots and streaks upon the front, there were to be seen two large stains on either side of the middle of the back of the garment, each about four inches long by three inches wide, such as might occur from any fluid running down the inside of the thighs from the vulva of a female lying upon her back in a nearly horizontal posture. My first duty being obviously to determine whether these reddish stains were produced by blood, the chemise was doubled over at the most highly tinted part of one spot, and the convex portion of the fold scraped lightly with a sharp scalpel over a clean slide until a small quantity of fine reddish dust was obtained. This powder was covered with thin glass, and, a drop of water being applied to one edge, and a fragment of bibulous paper to the other, a current of fresh fluid was kept up for about one minute (see page 285), when the specimen was examined with a power of 1200 diameters. Among the numerous fragments of cotton fibers, and in many cases attached to these, were to be seen whitish transparent masses, composed of very faintly outlined rounded and oval cells closely aggregated together, and evidently deformed by mutual pressure, while here and there appeared granular rounded or oval bodies, somewhat larger and less distorted in their aspect. (See Fig. 27.) Both these cellular elements became more clearly visible when slightly tinted with aniline, and on measurement with the micrometer were found to average about $\frac{1}{4000}$ and $\frac{1}{3000}$ of an inch in diameter respectively, whence I concluded that the

red stains were produced by blood, probably that of a human being.

On careful consideration of the general aspects of the case, it seemed to me that the supposition of willful deception, which the presence of vaginal epithelium in the scrapings, and also in the washings subsequently examined (without cells from the uterine mucous membrane, as would have been the case had menstrual blood been ingeniously used to produce spots voluntarily made for the purpose of substantiating a false charge), rendered very improbable, might be put aside. The main question, as to the presence or absence of spermatozoa, still continuing unsolved, as none had been detected among the particles of blood-clot, a fragment of muslin about three-fourths of an inch long by one-eighth of an inch wide, selected from a

FIG. 28.



FRAGMENTS OF SPERMATOZOA, from Stain upon a Chemise in case of supposed Rape. × 2800 Diameters (1-50th).

portion where the fabric although but little stained was a good deal stiffened by the suspected material, was cut out

with a pair of curved scissors, and, after soaking for a couple of minutes in a drop or two of weak glycerin and water (p. 37), its inner surface was gently scraped and pressed with a scalpel, the visible filaments of cotton picked out with a mounted needle, the remainder covered with a very thin glass and subjected to examination under a Powell and Lealand's $\frac{1}{50}$, giving a power of about 2800 diameters. Several indubitable spermatozoa, nearly all, however, more or less broken, as will be seen by reference to Fig. 28, were readily detected, and proved beyond all question that spermatic fluid, mingled with blood, had caused the stains upon the chemise. The spermatozoon on the right of the drawing, represented as lying upon its side, appeared to have been in great measure protected by its attachment to a squamous epithelial cell, probably from the vagina.

Dr. Caspar, in his Hand-Book of the Practice of Forensic Medicine, vol. i., Sydenham Society's translation, London, 1861, recommends for the investigation of stains of semen the method of Koblank, as at once the best and simplest. "A piece of the linen containing the suspected spot is cut out and placed in a porcelain saucer containing a few drops of cold distilled water; the linen is then to be thoroughly and carefully moistened by gentle and careful pressure and moving about with a glass rod; after a quarter of an hour a single drop of the water is to be gently squeezed by the finger from the linen upon a clean glass slide, and, should the stain have been truly seminal, the zoosperms will be at once readily recognized on bringing the slide under the microscope. Inexperienced persons may no doubt be deceived by the presence of epithelial cells, the fibers of the linen, etc., but whoever has only once seen a single characteristic spermatozoon, dead or alive, can never be deceived again. I have recognized them even after the lapse of an entire year, and thereby determined the existence of a seminal stain. Bayard states that he

has recognized them after three years, and Ritter even after four years, which is perfectly credible, presupposing always that the linen during that long time has not been much rubbed or handled, because the forms of the zoosperms will be thereby destroyed. After a considerable time indeed they fall to pieces of themselves, and then nothing is commoner than to find only mutilated specimens, heads, and filaments separate; but one single perfect zoosperm gives complete certainty as to the actual presence of a seminal stain. If the careful examination of an experienced eye has failed in detecting a single animalcule, after repeated examination, the medical jurist must declare that, whatever may be the probabilities, no evidence exists to prove that the stain examined has been caused by semen."

To these very judicious remarks of Dr. Caspar I may add that the appearance of spermatozoa under a high objective (much more powerful than any in existence at the time he wrote) is so very characteristic that I should have no hesitation in pronouncing that stain a seminal one in which I could detect two heads of spermatozoa (Fig. 28), with only a fourth part of their tails attached, even though no complete specimen could be found. I would suggest that any one undertaking such a research should acquaint himself with the appearances broken spermatozoa present when moistened with glycerin and water after desiccation, by preparing a few spots upon muslin with drops of deposit from urine containing spermatozoa (see Chapter IV. p. 99), and then testing fragments cut out as above described. Novices may find it advantageous to add a drop of aniline solution, as advised on p. 45, and by thus tinting the spermatozoa (see Fig. 8) insure their recognition.

MM. Briand, Chaudé, and De Claubry, in their Manuel Complet de Médecine Légale, Paris, 1852, p. 807, mention sundry chemical tests for seminal stains, and recommend the following method for the detection of spermatozoa:

"One should macerate threads of the tissue in distilled water for twenty-four hours, taking care not to rub them, and filter the liquor; the tissue should then be again immersed in water, which must be heated to a temperature of 60° to 70° Cent., and also filtered; finally, the fabric should be treated with a weak solution of alcohol, or with water to which a little ammonia has been added, and again throw it upon the filter. All these products having been thus treated, the filter containing their solid ingredients is removed, about an inch of its point is to be cut off, and, being opened out, spread face downward upon a watch-glass, or in a little flat cup such as is often used with the microscope, when it is to be soaked again with alcohol and water, or a solution of ammonia, which dissolves the mucus. After a short time we may carefully raise up the paper, which leaves upon the glass the zoosperms and all the substances which may be insoluble in the menstrua employed, and if these include only oil globules, we may cause them to disappear by the addition of a little ether." This mode of examination is of course most applicable to instances where a stain or stains of considerable size are at the disposal of the microscopist; although much more intricate than the plan described previously, it may sometimes be used to advantage in cases where, the chief evidence being circumstantial, the corroboration of a variety of methods is required.

The medical jurist may occasionally be required to give an opinion as to whether specimens of spermatozoa he has detected are really those of man, and not testicular products of some other animal, employed for the purpose of deception. Under such circumstances accurate measurements would be very important, and since these differ in the different species of mammals, and still more in birds, fishes, etc., they would probably be conclusive. Of course, counsel propounding such a theory to account for a suspi-

cious stain proved to contain spermatozoa should rightfully be compelled to show some probability of access to the one of the inferior animals from which they could be presumed to be derived. Of these the more likely are perhaps the dog, whose spermatozoa as figured by Rudolph Wagner (Elements of Physiology, translated by Robert Willis, M.D., London, 1844, p. 11) are about one-fourth larger than those of man, and have the body broadest at the extremity, instead of at the base; that of the rabbit, in which the body is nearly twice the size of the same part of a human spermatozoon, etc. The seminal animalcules of the monkey tribe closely resemble those of man, but are about one-half larger. Professor Dalton states (Human Physiology, Philadelphia, 1858, p. 458): "The spermatozoa of the human subject are about $\frac{1}{600}$ of an inch in length, according to the measurements of Kölliker. * * * The head constitutes about one-tenth part the entire length of the spermatozoon."

The important subject of the detection of poisons in very minute quantities by reactions which are so slight as to be quite imperceptible to the naked eye, although distinctly visible under the microscope, has been very fully, indeed, almost exhaustively, investigated by Prof. Theodore Wormley, of Starling Medical College, Ohio, in his elaborate work on the Micro-Chemistry of Poisons, New York, 1869, in which methods for the recognition of the $\frac{1}{100000}$ of a grain of Arsenious acid by the discovery of its octahedral crystals with a power of 150 diameters, also of the same infinitesimal quantity of hydrocyanic acid by the formation of microscopic crystals of cyanide of silver, are specifically described; to it the reader is referred, with full confidence that it will supply abundant information in regard to the matters of which it treats.

CHAPTER XV.

HINTS IN REGARD TO THE EXAMINATION OF MORBID GROWTHS.

WHILST a large number of the examinations of pathological formations in the human organism, coming as they do under the department of post-mortem researches, instead of investigations where the microscope is called upon to render assistance in the "diagnosis, prognosis, or treatment of disease," do not therefore constitute a part of Medical Microscopy in its strictest sense, yet as, in addition to those cases where a prognosis after operation not proving mortal is demanded, instances frequently are presented where great satisfaction may be given, not only to the physician but also to the family and friends of a deceased person, by the positive determination of the presence or absence of malignant disease, I will endeavor very briefly to indicate some of the rules which may best guide us towards a satisfactory completion of this duty to the survivors.

Since, by the labors of Virchow and others of his school, the doctrine of Lebert, who taught the existence of specific "cancer-cells" always, and only, to be found in cases of cancerous disease, has been overthrown, it becomes a matter of necessity that the results of microscopic investigation shall be considered, not as absolute proofs, but only as important data, which, when carefully weighed in conjunction with the naked-eye appearances, the seat of the affection and its mode of development, the constitutional

symptoms, history, and circumstances of the patient, etc., will generally enable us to arrive at a correct conclusion. I say generally, because I freely admit that there are some cases which I am not able to determine, and firmly believe that instances occasionally occur whose nature, with our present knowledge, it is utterly beyond the power of any microscopist to decide. On the other hand, however, the student can comfort himself with the assurance that he will meet with numerous examples of malignant and non-malignant growths, where, with ordinary care and attention, he may with confidence promptly answer the questions propounded to him; and just as he gains more experience in the work and becomes more skillful in the use of his microscope will the proportion of insoluble problems diminish, until their number becomes very small indeed.

When a morbid growth, or a formation suspected of being such, is offered to us for examination, if it is either a tumor removed during life or a post-mortem specimen, we may proceed, first, to select some portion of the structure in which its characteristic peculiarities, as estimated by the naked-eye appearances, are best developed; and this will generally be found in the central, as the oldest, part of the tumor, except where this has advanced to the stage of fatty degeneration (with or without the formation of pus), in which case better results will be obtained by investigation of specimens chosen from the more peripheral regions of the growth. Sections cut from the outskirts of the tumor often yield only negative results, for, as remarked by Virchow (Cellular Pathology, translated by Chance, Phila. reprint, 1863, p. 498), "There is a stage when it is impossible to decide with certainty whether we have in a part to deal with simple processes of growth, or with the development of a heteroplastic destructive growth."

In order to judge of a suitable point for investigation,

as suggested above, two or three incisions should be made into the substance of the tissue, and from the one determined upon a small portion of the fluid or "juice" (if any) which exudes upon the cut surface, or can be made to appear by scraping and pressing that surface with the edge of a sharp scalpel, should be removed upon the knife-blade, deposited upon a slide, covered with thin glass, and submitted to examination first beneath a power of about 200, and afterwards with higher objectives. The amount and character of the juice, as it flows out beneath the knife, should be carefully noted, since, as will be detailed further on, much stress is placed by some authorities upon its scarcity or abundance. Should the tumor be so dry and juiceless that more fluid is required to moisten the scrapings of the cut surface, resort should be had to weak syrup or glycerin and water of 1028 sp. gr. (p. 37), in order to avoid altering the form of any cellular elements which may be present. After a careful examination of specimens under these, as far as possible, normal conditions, a very small drop of acetic acid may be applied at one edge of the cover, and allowed to act upon the cells as it flows in among them, the fact of its entrance being verified by observing cells whirled along in the currents, and by seeing it cause the ordinary changes in the Leucocytes (see page 160, also Fig. 10). A small drop of aniline solution should then be introduced at the opposite edge of the covering glass, and its effects upon the structures under investigation (defining cell-walls, bringing into view nuclei and nucleoli, etc.) likewise carefully observed. If, as often happens, small globules resembling oil drops (Fig. 14) puzzle the microscopist with the suspicion that they may be fungi, altered blood disks, etc., they should be tested by sulphuric ether, which can be best applied to the margin of the covering glass by means of a tube pipette with an unusually fine capillary opening; but so volatile

is this reagent that much experience in its use is generally necessary before the observer can retain any small floating object in the field of view, whilst, on the other hand, beginners are apt to imagine that Ether has no effect upon the globules before them, when the fact is the ethereal current has quite failed to reach the portion of the slide beneath the objective.

After the fluids of the tumor and their contained cellular elements have been rigidly inspected, the investigation should be concluded by the examination of thin sections cut from various portions of the growth, some of which should comprise the margins of the pathological formation, and, if possible, extend into the normal tissues adjacent; and since this difficulty of cutting slices thin enough is one of the greatest obstacles in the way of the young microscopist, some particular directions may not be unacceptable. I think that one of the chief causes of the student's want of success is that he tries to prepare his sections too large, forgetting that the merest fragment (absolutely not larger than this note of exclamation, !) will, when magnified 200 times, fill several fields of view and prove quite sufficient to reveal the structure of a growth. In tissues not softer than an ordinary kidney, I would therefore recommend that the observer, having provided himself with a sharp razor or scalpel, should prepare a small parallelopipedon of tumor substance about half an inch long, a quarter of an inch wide, and one-eighth of an inch thick, which may be held firmly between the finger and thumb of the left hand (in a fold of muslin if preferred by a tyro), while a thin *wedge* is cut from one of its edges with the razor previously wetted with glycerin and water or weak syrup. This wedge should be turned round upon the blade of the razor with a mounted needle, and then drawn gently off (of course by its thicker extremity or head) on to a slide, where its thin

edge is to be floated out in a drop of fluid, cut off by a scalpel applied perpendicularly, so as not to disturb the relations of its parts, and covered with an ordinary glass film ready for examination. As I have seen a student prepare in this way, after a few trials, sections thin enough even for my $\frac{1}{25}$, I cannot but hope that it will prove generally feasible, and contribute to do away with one of the great difficulties in the path of the juvenile microscopist. Of course, as experience is gained, larger and larger sections can be cut, and, as in other affairs of life, "the little end of the wedge" will no longer be the chief object of solicitude.

For soft tissues we resort to Stricker's method of "Embedding," by placing the structure in a little folded paper tray, pouring over it melted wax and oil (equal parts), and when cold cutting thin slices of the compound mass held, if preferred, in a section cutter, such as Beale figures; or "tease" out a fragment with mounted needles; or wait some days, until by soaking in strong alcohol, or in chromic acid solution (2 gr. to the ounce) the structures we wish to examine have become sufficiently hardened to bear the pressure of the razor's edge. In the moderately soft tumors we can sometimes snip off, with a pair of curved scissors, such as are used by oculists in operations for Entropion, a little wedge-shaped fragment, whose side or edge may be thin enough for our purpose. As a general rule, the section for examination should not be thicker than ordinary writing-paper, while for the higher powers much more delicate films are required. I am informed by my friend Dr. Wm. B. Corbit, of this city, that the method now in use in Prof. Rokitansky's Laboratory in Vienna is to place a small fragment of the soft tissue, from which a section is desired, between two flat strips of elder-pith (as lateral supports) in a "clamp" (a small hand-vise), and, after screwing this up firmly, to cut thin slices of pith and all from the part left projecting above

the jaws of the instrument, each slice being subsequently floated off the blade of the knife or razor, and spread out upon a slide, whence the particles of pith should be removed by needles.

After obtaining a suitable section, its examination should be conducted in the manner directed above for the investigation of the fluid matters, the same reagents being employed, with similar precautions.

Presuming that a satisfactory specimen has been procured, in which exist cellular elements, other than those of the blood (red and white corpuscles) or of the organ in which the growth was seated (hepatic cells in tumors of the liver, renal epithelium in those of the kidney, for example), I will now endeavor to make some suggestions in regard to their import, premising that these generalizations are subject to many exceptions in particular cases, and that I only offer them provisionally, and until those who find fault with them shall furnish some more accurate and comprehensive scheme of investigating pathological formations. Further, it must be remembered, as will be more fully explained near the close of this chapter, that, in the words of Virchow, our final decision in regard to the malignant or benignant nature of tumors "depends upon the answer to the question *whether they arise at a spot to which they belong, or not, and whether they produce a fluid which, when brought in contact with the neighboring parts, may there exercise an unfavorable, contagious, or irritative influence*," so that, for example, a growth composed of epithelial-like cells, which is homologous, and therefore (theoretically, at least) benignant, in the skin where it may appear as a condyloma, is, when developed in any other tissue (as the connective), heterologous, and, consequently, more or less malignant in its nature.

If the cellular elements of the specimen undergoing examination (either those present in the juice, floating in the

fluid around the edges of the thin section, or in the substance of the latter) present after the action of acetic acid and of aniline—

A. *No well-defined nuclei,* and if they are of a rounded and oval form, about $\frac{1}{2000}$ of an inch in their long diameter, they are probably what have for many years been recognized as Tubercle corpuscles (see p. 128), although the experiments and observations of Villemin, Burdon Sanderson, Bastian, Niemeyer, and others have so unsettled the views taught by Lebert, and for a long time so widely accepted, that it is now extremely difficult to define what constitutes a tubercular deposit, since recent writers seem inclining to the by no means novel opinion that its cells may be white blood corpuscles which have undergone outside the blood-vessels some abnormal or perhaps incomplete development. The student may best familiarize himself with "tubercle corpuscles" by examining a nodule from the lung of a patient dead of pulmonary tuberculosis.

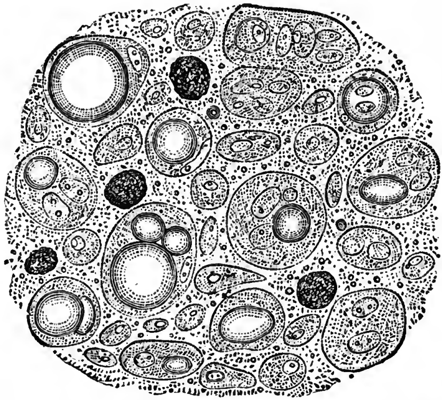
If the cells when treated as above exhibit—

B. *Well-defined nuclei,* their size and shape, as well as those of the cells in which they occur, must be carefully observed. Should the nuclei be very large, both actually ($\frac{1}{1000}$ of an inch across), and relatively to the magnitude of their cells (twice or three times the diameter of the nucleus found in a cell of epithelium from the mouth of similar size—see page 47), and many of the cells present an oval, caudate, or angular outline, and measure from $\frac{1}{1500}$ to $\frac{1}{400}$ of an inch in diameter, the growth, *if heterologous,* is probably cancerous.

a. Should the cells be rounded or oval, ranging from $\frac{1}{1500}$ to $\frac{1}{500}$ of an inch across (Collis, Diagnosis and Treatment of Cancer and the Tumors analogous to it, London, 1864, p. 15 *et seq*), with one, two, or three large oval nuclei, generally placed eccentrically (see Fig. 29), the cell-wall

pale, often obscured by oil globules, which seem to adhere to its inside, easily broken up by the usual chemical re-

FIG. 29.



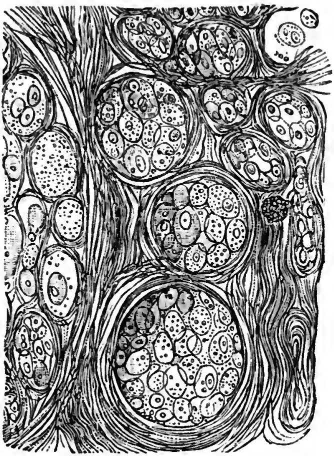
SIMPLE AND COMPOUND CANCER CELLS, from well-marked Encephaloid disease of the Duodenum. Several corpuscles "contain fluid from endosmose which strongly refracts light." (After Bennett.) × 250 Diameters.

agents (weak acetic acid, ether, iodine, potash, etc.), the nucleus dark and well defined, with a distinct shining nucleolus, the former very often obscured by the oil globules in the interior of the cell, but coming into view when the cell-wall is broken up and the oil globules are dispersed, provided the reagent used be sufficiently weak (otherwise it may also be broken up), we may, if the history and general symptoms accord with such an opinion, diagnosticate *Encephaloid disease.* (See page 320 *et seq.* for directions in doubtful cases.)

b. If the cells are polygonal, caudate, and angular, measure from $\frac{1}{1000}$ to $\frac{1}{400}$ of an inch across, and in the sections are frequently seen to exist as minute nodules of from five to fifty cells aggregated together in oval or rounded masses and imbedded in a more or less dense and abundant

stroma of fibrous tissue, we may, provided the other facts of the case consent, announce the presence of *Scirrhus*.* (See Fig. 30.)

FIG. 30.



Section showing the arrangement of CELLS and STROMA in SCIRRHOUS CANCER of the Mamma. (After Bennett.) × 250 Diameters.

Mr. Collis (*op. cit.*) divides this variety of cancer into two forms, the Atrophic and the Lardaceous; the former term being applied to such kinds of malignant disease as reduce the size of an organ below its natural dimensions, as is often seen when it attacks the female mammæ. The more common form, lardaceous scirrhus, is characterized by presenting along with the cancer-cells a large deposit of fat; since it is essentially an infiltrating growth, we are often unable to recognize it as a distinct tumor, and in

* According to some authorities, there are not unfrequently examples of Acute Scirrhus, which so closely resemble Firm Encephaloid tumors, that the microscope may fail to demonstrate any morphological difference between them.

the breast it is indicated by "an increase in the size of the organ; a brawny feel and look in the skin, produced by its early infiltration with cancer-cells; early poisoning of the glands; and, in general, rather rapid progress."

c. If the growth is chiefly made up of a jelly-like matter (contained in little cysts or loculi varying from the size of a pin's head to that of a pea), and under the microscope seen to be composed of rounded or oval cells, small in size, with small nuclei associated with delicate fiber, it is a *Colloid tumor*, which, although generally classed as a form of cancer by the older writers, is not at present universally so considered.

d. Should the cells be large, more or less regularly oval or flask-shaped, with numerous oval nuclei, not so large as the nuclei of cancer, and departing but little from the relative magnitude of ordinary epithelium, inclosed in pale cell-walls so fragile that they readily break up, and allow many free nuclei to be seen in each specimen, we may provisionally diagnosticate the *Myeloid tumor* of Paget and Collis (Fibroplastic of Lebert), as Epulis, etc. These growths, arranged by Collis among the Cancroids, are a large class, including many tumors that are highly malignant in their later stages, though often perfectly amenable to treatment at first. They specially affect the gums and Schneiderian membrane; the fibrous periosteum is also a favorite seat. As a rule, they are much more local in their action than cancers, "although it is certainly impossible," says Collis, "to draw an accurate line between the two, many tumors occupying as they do the boundary of each form." According to Virchow, however (Review of his "Krankhaften Geschwülste," *American Journal of Medical Sciences*, June, 1865), the criterion for distinguishing the medullary sarcoma presenting round cells, from carcinoma, lies in the relation of the intercellular substance. The structure of the sarcoma is never alveolar, like that

of cancer, where the cells lie heaped together in meshes; on the contrary, each cell is separated from its neighbors by the intercellular substance. The latter may be reduced to a minimum, but the tissue is still homogeneous and not meshy. The danger of confounding sarcoma with cancer is especially great in that form called Sarcoma Giganto-cellulare, where the cells are multi-nucleated, and sometimes so large that they can be detected with the naked eye.*

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* Paget (Lectures on Surgical Pathology, 3d edition, London, 1870, p. 544) remarks, "The term Sarcoma has recently been revived by Virchow and other pathologists in Germany, and employed to designate a group of tumors 'the tissues forming which belong to the series of connective substances, but which are distinguished from the tumors formed of the connective tissues by the preponderating development of the cell-elements.' The tissue of granulations formed during the inflammatory irritation of the connective tissue is regarded as the normal prototype of these tumors."

The varieties of Sarcoma include—

"*a.* Tumors with spindle-shaped cells, the fibroplastic cells of Lebert (Spindel-zellen sarcoma, Recurrent fibroid tumors, Fibroplastic tumors).

"*b.* Tumors with colossal, many nucleated, myeloid cells (Riesenzellen sarcoma, Myeloid tumors).

"*c.* Tumors with small round cells like the lymph or white blood corpuscles, or pus, or granulation cells (Rund-zellen sarcoma, Granulations sarcoma, Glio- or Lympho-sarcoma).

"*d.* Tumors with stellate cells, and a gelatinous, shiny, intercellular substance, not unlike the material found in a myxoma (Myxo-sarcoma).

"*e.* Tumors with round or variously-shaped cells, most of which are of large size, and are usually imbedded in a fibrous matrix. In structure no well-defined character distinguishes these tumors from Carcinoma.

"*f.* Tumors in which the cells contain a considerable proportion of pigment, which is most frequently found in the cells described in the last group, in the tumors with round and with fusiform cells (Pigment sarcoma, Melanoma).

"In all these forms an intercellular substance occurs, which may be either homogeneous or fibrous, or which may present a delicate netlike or trabecular structure, such as is found in a lymphatic gland."

Mr. Paget, however, "is inclined to think that the group is too

e. If the cells composing the growth under examination are usually small, elongated, caudate, and oat-shaped, with small nuclei, and are associated with many free nuclei and young cells, all arranged in an irregularly fibrous manner, we probably have to deal with the Recurrent fibroid of Paget (Sarcoma fibro-cellulare of Virchow, Fibro-nucleated of Bennet). These tumors are firm, fleshy, and dry; tear with an imperfectly fibrous grain; when scraped, yield no milky juice, and are found to be tough when we attempt to break them up for minute inspection; in outline they are either globular, where they can grow freely, or, if restrained in one direction by fascia or bone, they take an oval or elongated form, but still preserving the globular tendency, even if grooved by a band of fascia or tendon.

Again, Virchow, "On Tumors, vol. ii. p. 177" (quoted by Prof. Tyson in his excellent paper on a case of Spindle-celled Sarcoma, Pennsylvania Hospital Reports, 1869, p. 243), observes, in speaking of *Sarcomata* generally, "Under all circumstances there remains the common type,—namely, a tissue in which cells and intercellular substance, even though the latter be reduced to a minimum, are united into a relatively firm and coherent structure, a structure which contains blood-vessels, and is in continuous connection with the adjacent connective tissue. In this, sarcoma is essentially distinguished from all epithelial formations and all cancers and cystic tumors, in which the essential part places itself *adjacent* to previously existing structures as something different, in which the specific elements of the tumor are laid down, not continuously, but more or less discontinuously, *in simple contiguity*."

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vague, and is made to embrace tumors which are too diverse, both in consistence, color, vascularity, structure, mode of growth, seat, course, and effects on the patient, to be included under one common term."

f. Should the cellular elements nearly resemble the normal ones of the part, differing but little in their size, shape, position, and appearance of their nuclei, etc., the tumor, if it originates from an epithelial surface, may be designated as an Epithelioma. Dr. Beale, who remarks that the so-called *Epithelial growths* resemble *Cancerous tumors* more closely than other structures, tabulates their chief differences thus :—

"Cancerous.	"Epithelial Growths.
"Cells not connected with the matrix in a regular manner, or forming laminæ.	"Cells connected with the matrix often forming distinct laminæ.
"Cells differing much from each other in size and form.	"Cells resembling each other in size and general outline.
"Cells readily separable from each other.	
"Cells not connected together at their margins; their edges seldom forming straight lines.	"Cells often cohering by their edges, which generally form straight lines; three or four cells being frequently found united together.
"Cells containing several smaller cells in their interior, often met with.	"Cells usually containing one nucleus.
"Nuclei, varying much in size and number, in different cells.	"Nuclei not varying much in size in different cells.
"Juice scraped from the cut surface containing many cells floating freely in the fluid and not connected with each other."	"Juice scraped from the cut surface containing small collections of cells which are often connected with each other."

According to Paget (*op. cit.*), in Epithelial cancers the natural structures of the papillæ are replaced by cancer structures, the cell, like epithelium, lying not only *upon* the papillæ but *within* them; thus constituting an essential distinction between such a cancerous growth and a simple warty or papillary one.

g. If the histological elements of the tumor as seen in a thin section have so far undergone an almost normal development into ordinary fibrous tissue that very few rounded cells

or nuclei can be discovered, and the growth is supplied with blood-vessels only to the extent necessary for its nutrition, it probably belongs to the *Fibrous tumors* (Fibromata). This form of morbid growth as typically developed in the uterus is generally round, imbedded in the substance of the organ, and bulging out, when of large size, equally on its peritoneal and mucous surfaces. It is also frequent as polypus of the nose and pharynx, fibrous tumor of the prostate gland, of the lobes of the ear, alæ of the nose, scrotum, etc.

h. If the fibrous tissue is supplied with a superabundance of blood-vessels which have become largely dilated, we have, according to Collis, when these enlarged vascular canals continue permeable, the *Erectile*, and when they become obstructed, the *Fibrocystic, tumor.* Should they attack bone or cartilage, they often become in time themselves the seat of *osseous* or *cartilaginous* growth, probably constituting one form of the Osteosarcomata and Chondrosarcomata of Virchow ; and should the abnormal formation occur in the substance of a nerve and be associated with an excessive development of nerve-cells and fibers, it is known by the name of *Neuroma.*

C. If on examination with the naked eye or under the microscope the cellular elements of the morbid growth are found to be of very minor importance, it may probably be classed among the following.

a. Should the tumor be made up of one or more cysts (filled with serum variously colored) whose walls show, where examined microscopically, no tendency in any part towards a more unhealthy growth, it is a simple *Cystic* one, such as are common in the ovaries and in the female mammæ.

b. If a disposition to the formation of small cysts, or to the production of a solid growth, is apparent in the parietes of the tumor, it may be denominated a *Proliferous cyst.* (This more or less adventitious formation may, and often

does, become cancerous, fibrous, etc., in which case of course an effort should be made to classify it according to the characters of its cellular elements as above described.) The *Adenoid* tumor of the breast, so fully described by Mr. Paget (Adenoma, see *op. cit.*, p. 558 *et seq.*), appears to be composed of a sero-cystic tumor, into which the growth of a tissue closely resembling if not identical with hypertrophied gland-structure has occurred.

c. Should the contents of the cyst be sebaceous matter, with a few epithelial cells imbedded therein, and perhaps crystals of Cholestearine, it may be styled a *Sebaceous tumor.* Such formations are generally small, and result from the obstruction and consequent irritation of a sebaceous gland.

d. If the substance of the growth is composed of the ordinary large, oval, fat vesicles of adipose tissue, it may be classified as a *Fatty tumor*, or *Lipoma.* The term *Steatoma,* according to Beale, is applied both to Fatty tumors which contain a quantity of fibrous tissue in addition to the fat vesicles, and to "encysted tumors originating in sebaceous follicles, and containing a soft, pulpy material, rich in fatty matter but not containing fat vesicles. The fat is in the form of small globules, or merely granular."

If the cellular elements of any of the morbid formations above mentioned become the seats of pigmentary deposit to such an extent that they cause the whole mass to present a brownish, purplish, or blackish color, the pathological condition is called *Melanosis.* Thus, we may have occurring simple *fibrinous melanosis,* where the microscope shows only the ordinary lymph cells of inflammation, filled with pigment granules; *melanotic cancer* (generally of the eyeball), where in like manner the cancer cells are stuffed with brown or black particles; and less frequently other forms of the disease.

By carefully following the foregoing scheme, students will, I trust, be enabled to classify a majority of the morbid growths which come under their notice; but among the remainder some will be found which the contradictory results of naked-eye inspection and microscopical research, local and general signs or symptoms, and history of the case, will render extremely difficult to place. This apparent conflict of our data (always, of course, explicable if we had but the knowledge and the capacity which would enable us to discover *all* the disturbing influences, whether subjective or objective, that produce it) may sometimes be dissipated by a second or even a third investigation of the entire evidence we can obtain; but if not, we must make an effort to estimate the *comparative* value of opposing testimony, and so arrive at a probable if not a positive diagnosis. Since the most important question to be determined is generally whether a particular tumor is malignant or not, the following suggestions may be of service as aids towards an accurate valuation of microscopical evidence in that respect.

When we can be sure that no epithelial cells from a normal cutaneous, mucous, or glandular structure have become mingled with the sample of morbid growth under examination, detection of large angular and polygonal cells floating abundantly in the juice scraped from a cut surface is strongly indicative of cancer; but any one who will puncture his finger and then *scrape* off the drop of blood that exudes, with a sharp scalpel will be convinced, by the thousands of epithelial cells he can find among the red disks (even when only a moderate force has been applied), how necessary is the most scrupulous care to avoid contamination. In a recent case in the lower surgical ward of the Pennsylvania Hospital, where I was requested to examine the discharge from a tumor, supposed to be malignant, seated beneath the chin of a patient, I

took the precaution of first pressing out some of the discharge, to wash away any foreign matters from the lips of the fistulous opening, and then to remove a portion of the fluid, by means of a syringe, from within the sinus, for investigation; and yet I was surprised to find on the second slide which I inspected, a fine specimen of Pediculus capitis, which must have come from the surface of the man's body, and probably was taken up from the margin of the opening, in spite of all my care.*

Great irregularity in the size and shape of cells which we can be certain have been developed in close juxtaposition with each other, is an important criterion of malignant growth, and by its degree will often give ground for a surmise as to the virulence of the malignant tendency. Although, as any one may satisfy himself by inspecting different layers of epithelial cells from the skin or a mucous membrane, those from the deeper strata have not only a different shape but vary in regard to the size of their nuclei, and, as remarked by Prof. Beale, cells may almost always be obtained from the urinary bladder which present all the sensible peculiarities so long considered characteristic of cancer cells (see Fig. 7, p. 98), yet it will, I think, almost always be found that elements of the same normal tissue, in the same stage of development, and therefore in close juxtaposition, present the same general appearance. Thus, for example, a middle-aged

* In this case, numerous polygonal and caudate cells, somewhat resembling cancer cells, although probably derived from the surface of the skin, were present; but in addition I found several fragments of tissue resembling that delineated in Fig. 30. Upon these a probable diagnosis of malignant disease was made, amply justified, as far as could be in that time, by the rapid progress of the affection during the succeeding month, at the end of which period the patient, unfortunately, left the Hospital, and was lost sight of.

patient, admitted into the men's medical ward of the Pennsylvania Hospital during the summer of 1869, with Bright's disease, presented on his entrance into the institution a malignant-looking sore in the palm of his right hand, from which, at the request of the attending physician, I obtained a little slice of tissue for the purpose of microscopical investigation. Notwithstanding the cancerous aspect of the ulcer, I found, on placing a fragment of the section I had procured, moistened with liquor potassæ, under a power of 1200 diameters, that the cellular elements were of nearly equal size, possessed nuclei of about the same magnitude, and were arranged quite symmetrically in layers superimposed upon each other. Chiefly on this evidence I gave the opinion that the growth was simply an irritated condyloma, and had the satisfaction of seeing it entirely disappear in the course of a few weeks, under appropriate treatment.

Mr. Paget states (p. 616, *op. cit.*) that he knows of no innocent tumors, except the cartilaginous, in which this multiformity of cell contour is imitated.

The occurrence of fatty degeneration, as shown under a high objective by the appearance of minute globular particles of oil, similar to those drawn in Renal Epithelium in Fig. 6, is likewise an important assistance in the diagnosis of cancerous growth, since, although epithelial cells from the mucous membranes and the cutaneous surface, as they advance in age exhibit a granular appearance, which under a moderate power presents a similar aspect, when sufficiently magnified this condition may be often seen to originate in the very minute cylindrical spores of low forms of vegetable life (Bacterida) developed in their substance as their own vitality wanes. Of course, when we are able to satisfy ourselves that the cellular elements under examination have not been contaminated by any mixture with normal epithelial cells, recognition of this

granular appearance, with even a low objective, is a valuable criterion; and, indeed, in well-marked cases of malignant tumor, especially when rapidly growing, the amount of fatty degeneration is so great that the granular appearance far exceeds any produced by the development of fungi, approximating very closely to that presented by renal epithelium in severe cases of advanced Bright's disease. (See Fig. 5, *f* and *g*.)

Another important indication of malignant disease is the discovery of cells containing two, three, or more nuclei, and of others, the so-called mother-cells, which are composed of from two to ten small cells, inclosed within one common envelope. Both of these characteristics are so rare in the superficial layers of epithelium in its normal condition that in many cases where they occur abundantly in the juice of a suspicious tumor they may be considered almost pathognomonic of carcinoma.

In numerous instances I have noticed that the nuclei of cells from undoubted cases of cancer, when very highly magnified, were much more irregular in their outline than those of epithelial cells ever appear to be; they also showed a tendency to coalesce (when more than one existed) at their edges. Instead of the slightly eccentric position usually occupied by the nucleus of an epithelial cell, the corresponding portion of a cancer cell frequently varies in its situation relative to the parietes, sometimes occupying the exact center, at others filling up one extremity, or closely applying itself to the side of the cell-wall.

Dr. Beale states that "it is impossible to lay down any definite characters which shall in every case serve to distinguish a cancerous tumor from other forms of morbid growths; but a tumor from the cut surface of which a milky juice is poured out, and which, upon microscopical examination, is found to consist principally of cells, exhibiting the general characters above referred to, and arranged

in the meshes of a fibrous stroma, may be pronounced to be of a cancerous nature."

In regard to the type of malignant formation, Mr. Collis asserts that cancer secondary to either scirrhous or encephaloid is always of the latter character; and Paget remarks that of 100 primary hard cancers he believes that not less than 95 will be found in the breast.

The microscopist will sometimes be called upon, after examining a tumor removed during the lifetime of a patient to express an opinion as to whether the disease is or is not likely to recur, and in the former instance as to what period will elapse before such return of the complaint may be expected. In arriving at any conclusion in regard to these points, he must remember that not alone by the characters of the cellular elements composing the growth, but by all the circumstances of the case taken in conjunction with these, can he arrive at a conclusion which will be even approximatively accurate. Thus, as remarked by Virchow (Cellular Pathology, p. 530): "Cancer, cancroid, or epithelioma, pearly tumors or cholesteatoma, nay, perhaps the dermoid growths which produce hairs, teeth, and sebaceous glands, and so frequently occur in the ovary, all these are formations in which there is a pathological production of epithelial cells; but they constitute a graduated series of different kinds, which extends from those which are entirely local, and, in the usual meaning of the word, perfectly benignant, to the extremest malignity. The mere form of the cells which compose a structure is of no decisive value. Cancer is not malignant because it contains heterologous cells, nor cancroid benignant because its cells are homologous; they are both malignant, and their malignity only differs in degree. The forms which yield dry, juiceless masses are relatively benignant; those which produce succulent tissues have always more or less a malignant character. * * * Cancroid remains for a

very long time local, so that the nearest lymphatic glands often do not become affected until after the lapse of years, and then again the process is for a long time confined to the disease of the lymphatic glands, so that a general outbreak of the disease in all parts of the body does not take place until late, and only in rare instances. In cancer proper the local progress is often very rapid, and the disease early becomes general; a cure even for a short period is so rare that in France the complete incurability of cancer, properly so called, has been asserted and maintained with success."

The PROGNOSIS in well-marked *Encephaloid disease* is, as is well known, extremely unfavorable,—recovery, with or without operation, being rare. In *Scirrhus*, the prospect of cure is a little less hopeless and the probable duration of life decidedly greater, being in a typical case, according to Paget's statistics (*op. cit.*, pp. 649, 695), four years, while a like example of Encephaloid would probably arrive at a fatal termination within about half that time.

Of *Myeloid* or *Fibro-plastic tumors*, Mr. Collis declares that they are often perfectly amenable to treatment at first, and narrates some cases in which operation proved completely successful, although in the majority of instances a return of the malady in the cicatrix must be anticipated.

According to the same author, *Recurrent Fibroid* (Paget) "is far less malignant than cancer, prone to recur, yet not incapable of ultimate cure," by repeated operation. "It is about equally removed from cancers on the one hand and simple fibrous tumors on the other."

Fibrous tumors, including the Erectile, Cystic, and Neuromatous tumors, do not, with rare exceptions, poison the glands or system, and "when removed completely they do not seem to return; but it must be manifest that some of them are so circumstanced as to be incapable of

complete removal;" and the same remarks apply as a general rule to *Fatty tumors* with equal force.

The progress of *Epithelioma* after removal by any operation varies so much with the seat of the disease, and indeed in any case is so extremely uncertain, that I fear no satisfactory rules can be given in regard to it in the present state of our knowledge, except the general one laid down by Virchow and quoted above. In a majority of cases, after operation, sooner or later it recurs, either in the cicatrix or the neighboring glands; but in a considerable number of instances, forming a much larger percentage than is the case with cancer, a permanent cure appears to be effected.

APPENDIX A.

LIST OF MICROSCOPE MAKERS AND DEALERS.

Boston Optical Works, C. H. Stoddar, Treasurer; R. B. Tolles, Superintendent; No. 66 Milk St., Boston, Mass.
Grunow, J. and W., No. 52 E. 30th St., New York.
Hartnack and Oberhäuser, Place Dauphiné 21, Paris.
McAllister, T. N., No. 49 Nassau St., New York.
McAllister, W. Y., No. 728 Chestnut St., Phila., Pa.
Nachet, Rue St. Severin 17, Paris, France.
Powell & Lealand, No. 170 Euston Road, London, Eng.
Queen, J. W., & Co., No. 924 Chestnut St., Phila., Pa.
Ross, No. 53 Wigmore St., London, W., England.
Smith, Beck & Beck, 31 Cornhill, London, England.
Tolles, R. B. See Boston Optical Works.
Wales, William, Fort Lee, New Jersey.
Zentmayer, Joseph, No. 147 S. Fourth St., Phila., Pa.

APPENDIX B.

LIST OF WORKS ON THE MICROSCOPE, ETC.

TO THE AUTHORS OF MOST OF WHICH THE WRITER GRATEFULLY ACKNOWLEDGES HIS INDEBTEDNESS.

Anderson, D. M'Call, Parasitic Affections of the Skin, London, 1868.

Beale, Prof. L. S., Microscope in Practical Medicine, 3d Edition (Phila.), 1867.

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THE END.